

UNIVERSITY OF BRISTOL.



THE ANNUAL REPORT

OF THE

Agricultural and Horticultural
Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL,
1938.

LONDON AND BATH:

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INTRODUCTION.

By B. T. P. BARKER, M.A., Director.

The Annual Report for 1937, while recording little change as far as the Department of Agriculture and Horticulture as a whole was concerned, referred to possible impending developments of a major order in respect of its organization and administration. It was recognized that the constant growth and extension of its activities at the three constituent working centres—the Research Stations at Long Ashton and Chipping Campden and the Provincial Agricultural Advisory Centre at Bristol—were rendering revision of the existing system of government and control increasingly desirable. Such issues inevitably involved consideration of the relationship of the University and the external organizations directly interested and the respective responsibilities of each. The formation of an *ad hoc* Committee to review the situation generally and formulate proposals for such readjustment as seemed desirable was mentioned in last year's Report. Although other matters of more immediate urgency have prevented full consideration by that Committee of all the subjects covered by its terms of reference, several important decisions arising from its interim recommendations have been taken and put into effect. Of these, the following call for mention here.

Finance and Property.

Firstly, the position of the University in relation to the finances of the Department and the ownership of and degree of responsibility for the various properties concerned has been clarified. As a consequence a much closer liaison has been established between the University Finance Committee and the Agricultural Committee. The annual estimates of the Department which have to be submitted for the assessment of the Government grants in aid of its work are to be prepared in consultation with the University Bursar, Mr. Ivor Fox, who heretofore was associated personally only with the annual audit of the accounts. The complicated and ambiguous forms of presentation of the estimates and the accounts previously in use have been simplified greatly as a result of discussions between the Bursar, the Head of the Department and representative Government officials. This simplification has shown much more clearly and prominently the inadequacy of the existing rates of the Government grants-in-aid for the work which the Department

has been called upon to undertake. As a natural corollary, it has also brought more obviously into notice the very considerable contributions towards the cost of the work over a long period of years from the University's side, and the serious encroachment on the reserves of the Department, which now have been diminished almost to vanishing point.

This general survey of the financial position now seems likely to lead to a favourable revision of the amounts of the Government grants for future years, more in keeping with the essential expenditure. It is recognized on both sides that, unless this course is followed, the work of the Department must be reduced substantially, an alternative undesirable to face and difficult to achieve in view of the demands for its services and the admitted value of the work at each of its Centres.

Another result has been to bring the buildings, land and other property of the Department at Long Ashton directly under the supervision of the Bursar and the Clerk of Works of the University.

No rearrangement of this kind was required in the case of the Agricultural Advisory Centre at Berkeley Square, as the work there has been housed from the time of its establishment in buildings already the absolute property of the University, and coming automatically therefore under the charge of the Bursar for their maintenance and any needed structural alterations and new equipment. The buildings and land at the Campden Research Station, being Government property, are under the charge of the Office of Works and are periodically inspected by officials attached to that Office. The University's responsibility in that instance is limited to matters of maintenance and minor structural alterations and repairs arising from the reports of the Inspectors.

Provincial Advisory Conference.

One further important change in organization affecting the Department put into force during 1938 calls for notice at this stage. This relates to the Provincial Advisory Conference of the Bristol Advisory Province. The Province proper is comprised of the counties of Gloucester, Hereford, Somerset, Wiltshire and Worcester for all agricultural and horticultural matters. In addition, Devon, Dorset and Monmouth are included as supplementary counties for horticulture only, in view of the financial and other links between them and the Long Ashton Station. The members of the Conference include representatives of the county agricultural education staffs, the members of the staff of the Provincial Advisory Centre located at Bristol and Long Ashton, and the Director and Deputy Director of the Long Ashton Research Station. Meetings of the

full Conference have generally been held quarterly, in addition to other meetings, as required, of the special Sub-Committees for Agriculture, Dairying, Poultry and Horticulture. An Executive Committee, composed of the County Agricultural Organizers in the Province, a representative of the Ministry of Agriculture and Fisheries, the Chairmen of the Sub-Committees, the Chief Advisory Officer and the Head of the Department, was responsible for the general co-ordination of the various activities of the Conference and matters concerned with the Advisory Service within the Province.

The extension of work in the respective counties of the Province and the expansion of the staff and range of work on the University side led ultimately to so large a membership of the Conference that the system of organization outlined above proved unwieldy. Also it did not provide for other organizations within the area which, while not officially integral parts of the Advisory Service—their functions being primarily or exclusively for education or research—nevertheless could not be entirely dissociated from advisory work.

Proposals for enlarging the scope of the Conference have been, therefore, now put into effect after approval by the University. Provision has been made for representation of all institutions and organizations concerned with agricultural research, advisory work and education within the Province and in receipt of grants from public funds. This arrangement has enabled the Royal Agricultural College, Cirencester, the Campden Research Station, various other Departments of the Faculty of Science in the University, and the Avoncroft College, Stoke Prior, Bromsgrove, to participate. The organization of the Conference has been placed in the charge of an executive body—the Provincial Advisory Council—composed of the members of the previous Executive Committee, with the exception of the Chairmen of the Sub-Committees, whilst the Deputy Director of Long Ashton and the Heads of the new institutions and other bodies now qualified for representation have been added. The various Sub-Committees under the earlier scheme now have become Sectional Committees and meet as often as may be necessary, reporting directly to the Council: while the full Conference itself normally will meet once a year to receive the annual report of the Council and deal with subjects of general interest to the constituent bodies as a whole.

The changes have been designed to provide a constitution with sufficient flexibility and elasticity to incorporate any wider representation which may be approved from time to time, and thus maintain an organization through which the staffs of the University Departments and the Agricultural Education Offices of the counties of the Province can co-operate with representatives of any other organizations within the Province, having as a common objective the promotion of progress in Agriculture by research, technical advice and education.

THE BERKELEY SQUARE ADVISORY CENTRE.

Staff.

Mr. C. W. Harwood, B.A. (Bristol), was appointed Student Assistant in the Agricultural Economics Section in July. He succeeded Mr. S. R. Wragg, M.A., who resigned in June in order to take up an appointment at Reading University.

Mr. J. S. Garside, M.R.C.V.S., D.V.S.M., resigned his post as Poultry Pathologist at the end of September in order to take up an appointment as a Veterinary Officer under the State Veterinary Service. Miss E. H. L. Duncan, M.A., B.Sc. (late of the Wellcome Research Laboratories), has been appointed in his stead.

Two new appointments made for the Lime and Phosphate Deficiency Soil Survey were awarded to Mr. R. A. Pullin, M.R.A.C., N.D.A., and Mr. F. J. Marshall, N.D.A.

General.

In the last Annual Report reference was made to the Land Fertility Scheme of His Majesty's Government and its reaction on the work at the Advisory Centre. It was envisaged that there would be a large increase in the number of soils submitted for examination. The increase has been larger than was anticipated, but it has been possible to cope with the work, as additional financial assistance was provided by the Ministry of Agriculture to enable the appointment of further assistant laboratory staff.

Another notable development has been the Lime and Phosphate Deficiency Soil Survey. Provision was made in October, 1938, by the Ministry of Agriculture for the appointment of two "field" men to go into "backward" areas in the counties of the Province and there to take soil samples for analysis. These samples are analysed at the Centre and the results are recorded on 6 inch ordnance survey maps. It should be mentioned that a complete set of such maps for the whole Province has been given to the Centre by the Ministry, and duplicate copies are held by the County Agricultural Organizers for their respective counties. The Survey is proving extremely valuable and a detailed picture is now being obtained of the fertility status of soils in selected areas in the Province. Although the official scheme does not include the examination of the soil for potash status, this constituent is determined on all samples submitted: the work to date has revealed a serious and widespread deficiency of potash in soils.

The experiments in conjunction with the British Basic Slag Corporation Limited, to study the lime value of low-grade and high-grade basic slags on acid grassland have been continued and the grant of £100 per annum has been renewed for another year.

A grant has been made by the Chilian Nitrate Corporation Limited, for an "exact" experiment with regard to the manuring of grassland. This is being carried out at the Research Station, Long Ashton.

The grant of £100 from the Bath and West and Southern Counties Agricultural Society towards an investigation of the nutritive value of hay has been renewed for another year.

THE LONG ASHTON RESEARCH STATION.

Staff.

Staff changes and additions during the year have not been numerous, although in some instances they have been of a character significant of impending developments in the work of the Sections affected as soon as the financial position of the Station and the general situation become more favourable for them to be given full effect.

After a comparatively short tenure of three years in charge of the Home Kitchen Section, which deals with research, advisory and educational work on Domestic Methods of Fruit and Vegetable Preservation, Miss J. Ferguson, M.Sc., gave up her post at the end of January, 1938, on the occasion of her marriage. She has been succeeded by Miss B. A. Crang, B.Sc. (London), who brings to that branch of the work a period of experience in the Fruit Section of the Hammersmith Research Laboratories of Messrs. J. Lyons & Co., which should enable her to view the problems from the applied side also.

Marriage is also responsible for the resignation of Miss E. S. Smyth, Ph.D., who, although giving up her post as Plant Physiologist at the end of June, 1938, is still able to keep in touch with the various activities of the Station as the wife of the Deputy-Director, Dr. T. Wallace. To both of them the best wishes of all connected with the Department are assured.

The vacancy thus created on the research staff of the Plant Physiology and Pomology Section has been met by the promotion of Mr. W. E. Berry, Ph.D. (Leeds), who has been closely associated with the work of that Section during the later years of Dr. Swarbrick's

tenure of the position of Plantations Officer. It has been possible also to make arrangements for the latter to devote the whole of his time to research again. By the appointment of Mr. E. W. Hobbis, N.D.H., as Plantations Officer, Dr. Swarbrick is now able to resume active work on a programme of investigations to an extent impossible while subject to the dual calls of the management of the fruit plantations and his personal researches on pomological and physiological problems. Mr. Hobbis joins the staff of the Station after previous wide experience in the management of commercial fruit plantations in the south-eastern counties and the educational, advisory and experimental work associated with the position of County Horticultural Superintendent in Worcestershire.

Mr. C. J. Hickman, M.Sc., who had been associated with Mr. Ogilvie in the Mycological Advisory Department for diseases of vegetables in particular, retired from his appointment on being placed in charge of investigations concerning strawberry root rot at Westerham, Kent, under the Agricultural Research Council. He has been succeeded in his post at Long Ashton by Mr. H. E. Croxall, B.Sc. (Birmingham), who commenced his duties at the end of April, 1938.

Another appointment associated with disease and pest control work has been that of Mr. E. H. Wilkinson, B.Sc. (Birmingham), who continued the section of this work for which special arrangements with Imperial Chemical Industries, Ltd., had been made. At the termination of this grant at the end of July, 1938, he was awarded a scholarship for further investigations on disease and pest control, for which a special grant was received from Technical Products, Ltd.

In the Fruit Products Section, Mr. R. Curtis, B.Sc., who had been assisting Mr. Charley in the joint experimental work with Messrs. H. W. Carter & Co., Ltd., referred to in the last two Annual Reports, resigned, having accepted a technical appointment with that firm. The Fruit Products Section staff has been increased as the result of an interim grant made by the Ministry of Agriculture and Fisheries to finance the creation of a new post, that of Microbiologist. To that post Mr. Hugh Dickson, D.Sc. (Lond.), was appointed during 1938. This new post represents the first stage in the further development of the scheme for the extension of that Section, which has been under consideration by the Ministry of Agriculture and the Agricultural Research Council for some time. It is anticipated that a further appointment in connection with this scheme will be sanctioned in time to take effect during the course of 1939. The financial arrangements associated with these new posts may be of a temporary

character as far as the Ministry of Agriculture is concerned, for the Department of Scientific and Industrial Research may undertake that responsibility at an early date in consequence of negotiations between it and the two other bodies mentioned above.

Buildings and Land.

Reference has already been made to the general financial position of the Department. Its effect on the work at Long Ashton, where expenditure must be rigidly restricted until the result of the re-assessment of the new Government grants has been decided, has been further complicated by the loss of revenue from the 1938 fruit crops in the plantations at the Station caused by the disastrous spring frosts and drought.

Consequently, except for extensions or modifications of work associated with the staff additions and changes recorded under the previous section, there has been little alteration as regards the buildings or land at the Station.

The new appointment of a microbiologist for the Fruit Products Section and the consequent developments of that branch of the work concerned with the production of unfermented apple juice have made necessary further inroads on the floor space in the main building of the cider premises. The alterations include the erection of a compartment adapted for the bottling of the unfermented juice and similar beverages under aseptic conditions. This will be available also as a sterile bottling-room for carbonated germ-free ciders.

This further encroachment on the space available for cider-making requirements in that building has entailed a considerable reduction in the quantity of cider made at the Station in the autumn of 1938. Lessened production is not a serious matter at the present juncture, for other reasons for the limitation of output also have existed. They can be more appropriately dealt with in detail in the next Annual Report, when the ciders made from the 1938 crop of fruit have matured and fall due for report in the normal way.

Working space in the laboratory building has become even more seriously congested than in other recent years, in consequence of the increase in the number of research workers and associated assistant staff. For some time it has been increasingly difficult to find bench space for any newcomer and the point has now been reached when the alternatives of an additional laboratory building or the non-acceptance of post-graduate students are being considered. The site of the present laboratory building does not offer any

adequate room for even a minor extension of the existing building ; thus the provision of the accommodation required is likely to be too costly to face at a time so unpropitious as the present.

With the whole of the suitable land at the Station now appropriated for the field experimental work, there would be under normal conditions little to record from one year to another with regard to the establishment of new fruit plots. The regularly recurrent heavy financial losses each year in connection with this branch of the work of the Station have enforced, however, a change of policy. This has for its objective the gradual replacement of the plots showing the greatest losses by others planned with closer regard to costs and returns. The Plantations Technical Sub-Committee has surveyed very carefully the whole area of the Plantations plot by plot, taking account of the past results and future prospects of each in those respects. The contemplated alterations of the previous programme are being proceeded with as rapidly as possible, as opportunity arises. Necessarily it will take time for the revised scheme in full operation to show its effects on the Plantations accounts ; but within the course of the next few years it is anticipated that the adverse balance between expenditure and income can be substantially reduced.

General.

Annual Field Day. The Annual Field Day at the Station was held on Thursday, May 5th. The programme on this occasion was on similar lines to that of the previous year. Once again the Ministry of Agriculture and Fisheries was represented with an exhibit relating to the Ministry's National Mark Schemes, staged in the Cider House. This attracted much attention and added considerably to the utility of the function.

The prizes in the Institute's Cider Competitions were distributed to the successful competitors during the course of the afternoon by H. V. Taylor, Esq., O.B.E., D.Sc., V.M.H., Horticultural Commissioner to the Ministry of Agriculture and Fisheries. The address given by him in connection therewith was very appropriate for the occasion and was listened to with much interest by the large crowd of visitors.

Visitors. On May 12th there was a further prize distribution function at the Station on the occasion of an Open Field Day for the presentation of the "Whiteway" Cups for Orchard Improve-

ment, arranged by the Devon County Agricultural Committee. For the first time this annual event was held outside the County of Devon. The prize distribution ceremony was presided over by R. H. Densham, Esq., J.P., Chairman of the Devon County Orchards Sub-Committee. An address was given by Stanley H. Badock, Esq., J.P., LL.D., Chairman of Council and Treasurer of the University of Bristol.

Another visit of interest to the Station during the course of the year was that of the Lord Mayor and Lady Mayoress of Bristol on September 19th.

Since the Imperial Fruit Show was held at Bristol in the autumn of the year, special arrangements were made at the Station for visitors to view the work at Long Ashton during the course of the Show week.

As usual, many individual visitors from various parts of Great Britain and Overseas were received by the Station during the year and, in addition, the following organized parties also paid visits :—

Somerset Teachers' Refresher Course.
 Reading University Students.
 Cornish Growers.
 Bristol Central Divisional Labour Party.
 Kingswood School, Bath, Naturalists' Club.
 Merchant Venturers' Technical College Pharmacy Students' Association.
 Bryanstone School, Blandford, Biology Class.
 Clifton College Scientific Society.
 National Co-operative Men's Guild
 Littleton and Badsey Growers, Ltd.
 Nailsea Horticultural Society.
 Eastern Counties Provincial Conference.
 Agricultural Bacteriologists' Conference.
 Bath and District Gardeners' Society.
 Backwell Women's Institute.
 St. Aldhelm's Ex-Choristers' Association.
 Board of Education Refresher Course.
 Royal Agricultural College Fruit and Vegetable Preservation Course
 Students.
 Miss M. E. Turner's Ladies' Club.
 Somerset Cider Makers.
 Fishponds Branch of Townswomen's Guild.

Show Exhibits. Educational exhibits were staged at the following agricultural and other shows along the usual lines.

Bath and West Show, Plymouth.
 Three Counties Show, Gloucester.
 Cheltenham Floral Fete, Cheltenham.
 Royal Agricultural Show, Cardiff.
 Melplash Agricultural Show, Beaminster.
 Gillingham and Shaftesbury Show, Gillingham.
 Abergavenny Horse Show, Abergavenny.
 Evesham Asparagus Show, Evesham.
 Imperial Fruit Show, Bristol.

Research Students and Voluntary Workers. During the course of the year the following post-graduate workers have been engaged in research at the Station :—Mr.D.L.G.Davies, B.Sc., Mr.H.H.Khan, B.Sc., Mr. Y. V. Rao, M.Sc., Mr. E. H. Wilkinson, B.Sc., Mr. A. F. Parker-Rhodes, B.A., Ag. Dip., Mr. D. M. Behura, B.Sc., Mr. M. I. Shah, M.Sc., and Mr. G. W. Parnell, B.Sc. Of these, Mr. D. L. G. Davies and Mr. H. H. Khan were awarded the Degree of Ph.D., and both have now left the Station to take up appointments elsewhere. In addition, Mr. A. Kiskis, of the University of Latvia, a British Council student who is in this country for twelve months for the purpose of studying English horticulture, has been at the Station since the beginning of November.

Acknowledgments. The Department has been associated with many institutions and individuals in conjoint work during the course of the year and to them it is desired to express warm appreciation of their collaboration. Generous help has also been given in various ways by many others. In tendering to all of them grateful thanks for their assistance it is especially gratifying to be able to record the widespread interest taken in the activities of the Department and the general goodwill shown towards it.

Throughout a year abnormal and difficult in many respects, an exceptional degree of responsibility and strain has had to be borne by the staff as a whole. All grades of workers have contributed in full measure to maintain the efficiency of the work as far as possible and have merited special acknowledgment.

SUMMARY OF RESULTS OF MANURIAL EXPERIMENTS ON BLACK CURRANTS, RASPBERRIES AND STRAWBERRIES AT LONG ASHTON, 1924 - 1937.

By T. WALLACE.

As a part of the programme of nutritional investigations on various fruits at Long Ashton, definite areas of land in the Research Station plantations have been allocated for long period manurial experiments.

During the period 1924-'37 three of these areas have been mainly or wholly devoted to experiments on black currants, raspberries and strawberries, and the results obtained in these to the end of the 1937 cropping season have recently been published in detail (3, 4, 5).

In the present paper a summary is given of the more important points which have emerged from the trials, special reference being made to practical aspects of the results.

A. BLACK CURRANTS.

Site and Soil.

The site utilized for the experiment is practically level, and is slightly low-lying and liable to be affected by late spring frosts.

The soil is classified as belonging to Series No. 6 of the Research Station soils (2) and is, in general, a brownish-red, fine sandy light loam. At the beginning of the experiment the surface soil and subsoil both contained over 1 per cent. of free calcium carbonate and available potash and phosphoric acid were low.

Plot Layout and Material.

The plots comprise a rectangle, measuring 60 yards by 42 yards

and divided into 18 plots, each 14 yards by 10 yards and arranged in three rows.

For the experiment, the area was completely planted in December, 1927, with black currants, variety Baldwin, at 6 ft. square, there being 24 experimental plants on each plot and the plots being separated from one another by buffer rows. The bushes were 2 years old when planted, and were cut to the ground after planting and grown as stools.

Manurial Treatments and Management.

Six experimental treatments were given as under, each in triplicate, and the plots were randomised to allow of statistical treatment of the data.

- | | |
|--------------|--|
| Treatment A. | No manure. |
| „ B. | Farmyard manure at 10 tons per acre annually. |
| „ C. | Complete artificials annually, consisting of nitrate of soda 4 cwts., superphosphate 3 cwts., and sulphate of potash 3 cwts. per acre. |
| „ D. | As C but omitting nitrate of soda. |
| „ E. | „ „ superphosphate. |
| „ F. | „ „ sulphate of potash. |

All manurial applications were made in March. Normal commercial management was given. An annual routine spraying programme was carried out: a winter wash of tar oil at 5-7½ per cent.; lime sulphur 1 in 12 in spring against Big Bud; and Bordeaux Mixture 2 : 4 : 50 immediately after picking the crop to control the Leaf Spot fungus, *Pseudopeziza Ribis*, which was prevalent throughout the experiment.

Results and Discussion.

Data were collected each year relating to general growth characters, weights of pruning wood removed, Leaf Scorch, incidence and effects of *Pseudopeziza* on defoliation and cropping. All quantitative records were made on an individual bush basis and were supplemented by detailed field notes. During the experiment it was necessary to discard certain bushes due to Reversion disease and *Armillaria mellea*, and these were omitted from the records.

General Growth Characters.

The main points requiring note are as follows:—

Growth was restricted from the outset where potash was not given and potash deficiency appeared to be the primary manurial problem; vigour was generally good where potash was given but tended to be weaker where nitrogen or phosphate was omitted; growth was very vigorous on the farmyard manure plots; *Pseudopeziza* was severe each year and caused premature defoliation, the attacks appearing to be decreased by potash deficiency and increased by a deficiency of either nitrogen or phosphate.

Data relating to vigour, Leaf Scorch, and effects of *Pseudopeziza* are shown in Tables I—III.

TABLE I.
VIGOUR RECORDS (3/8/37).

Plot.	1.	2.	3.
Treatment A. No manure	Medium to poor.	Fairly good.	Medium.
„ B. Farmyard manure ..	Very vigorous.	Very vigorous.	Very vigorous.
„ C. Complete artificials. .	Vigorous.	Vigorous.	Good.
„ D. Omit nitrogen ..	Good.	Medium.	Medium.
„ E. Omit phosphorus ..	Fairly good.	Medium.	Good.
„ F. Omit potassium ..	Medium.	Good.	Medium.

TABLE II.
NUMBERS OF BUSHES SHOWING LEAF SCORCH, 1/9/32.

Plot.	1.	2.	3.	Totals Scorched of 72 Bushes.
Treatment A ..	24	23	18	65
„ B ..	0	0	0	0
„ C ..	0	0	0	0
„ D ..	0	0	0	0
„ E ..	0	0	0	0
„ F ..	24	22	23	69

TABLE III.

INCIDENCE OF LEAF SPOT AS SHOWN BY % FOLIAGE RETAINED
(ORDER OF RETENTION IN BRACKETS).

Treatment.	27/10/32.	27/9/34.	19/10/36.	9/8/37.
A.	41 (2)	63 (2)	24 (3)	66 (3)
B.	36 (3)	58 (4)	29 (2)	76 (1)
C.	34 (4)	58 (5)	24 (3)	56 (4)
D.	33 (5)	61 (3)	22 (5)	52 (5)
E.	27 (6)	52 (6)	22 (5)	47 (6)
F.	56 (1)	67 (1)	40 (1)	72 (2)

Pruning Weights.

Pruning weights, per bush, were taken each year from planting as a rough measure of vigour.

Two analyses of the data were made with a view to determining differences shown over the whole period (1928-1937), and over the last three seasons (1935-1937). In Table IV the results for the various treatments are given as percentages of the prunings on the no manure plots and significant differences due to manuring are shown.

TABLE IV.

PRUNING DATA. TREATMENTS SHOWN AS % OF NO MANURE.

Treatment.	A. No Manure.	B. Farmyard Manure.	C. Complete Artificials.	D. Omit Nitrogen.	E. Omit Phosphorus.	F. Omit Potassium.
1928-1937	100	162	124	114	111	102
1935-1937	100	213 (Significant to 1%)	148	133	132	111

Although the results in Table IV show higher values for all the manured plots than for the no manure treatment, the only significant increase shown is for the farmyard manure treatment for the three year period. It is notable, however, that the treatments show the same order for the two periods and that for the later period the values are higher than for the whole.

Crop Yield and Quality.

Yield data were obtained for nine consecutive crops over the period 1929–37 inclusive; but, unfortunately, only three of these were satisfactorily high, 1930, 1931 and 1937. The light crops are to be attributed mainly to frost injury, which was severe in 1929, 1933, 1935 and 1936, and to injury from lime sulphur spray. *Pseudopeziza* also greatly affected yields. Data for the nine seasons (1929–37) and for 1937 alone are summarised on a percentage basis in Table V.

TABLE V.
CROP YIELDS. TREATMENTS SHOWN AS % OF NO MANURE.

	Treat- ment A. No Manure.	B. Farmyard Manure.	C. Complete Artificials.	D. Omit Nitrogen.	E. Omit Phosphorus.	F. Omit Potassium.
1929–37	100	194 (Significant to 1%)	162 (Significant to 5%)	142	129	104
1937	100	261 (Significant to 1%)	180 (Significant to 5%)	139	131	124

In this case the two treatments, farmyard manure and complete artificials, show significant increases in both analyses, whilst the results also indicate apparent increases in the cases of the other manurial treatments. The percentage increases for cropping are larger than those for prunings. The large apparent gain of Treatment F over Treatment A in 1937 against the 1929–37 period may be due to deficiencies of nitrogen and phosphate becoming operative under Treatment A in the later stages of the experiment, these also leading to greater severity in attacks of *Pseudopeziza*.

Detailed examinations of quality were made immediately after picking on bulks of fruit from the various plots in two seasons, 1935 and 1937, the former a light cropping year and the latter a heavy cropping one.

The salient points were as follows :—

July 18, 1935.

Size. Large for farmyard manure and complete artificials ; variable for no manure, omit K, P or N, especially the two former.

Ripeness. Uneven for no manure and omit K, and fair proportion of unripened fruit ; omit N tendency to over-ripeness.

Flavour. Full for farmyard manure and complete artificials ; omit N tendency to be sweet ; omit P tendency to be acid ; no manure and omit K variable, ripe fruits tendency to be sweet.

July 7, 1937.

The observations are summarised in Table VI.

TABLE VI.

Plot.	1.	2.	3.
Treatment A. No manure	Small, many red, striggy.	As A1.	As A1.
Treatment B. Farmyard manure ..	Size good, very slightly red.	As B1.	Large, few red and green
Treatment C. Complete artificials ..	Large, few red and green.	As C1.	As C1.
Treatment D. Omit nitrogen	Size good.	Size good, somewhat striggy.	Size good.
Treatment E. Omit phosphorus.. ..	Size large.	Size good.	As E2.
Treatment F. Omit potassium	Size variable, many red, striggy.	As F1.	As F1.

The outstanding point which emerged was the variability and delayed ripening on the no manure and omit K plots. There was a tendency to earlier ripening on the omit N plots in 1935.

Soil Data.

On the area used in this experiment it is proposed to follow the effects of cropping and manurial treatments on soil fertility data, and in this connection determinations were made on samples of surface soil (0 in. to 9 ins.) and subsoil (9 ins. to 18 ins.) taken from the no manure, farmyard manure and complete artificials plots in October, 1937, and compared with data from similar samples taken in February, 1928. The results showed the following points :

Hygroscopic Moisture. Considerable falls in values were shown for all subsoils, and for "no manure" and "complete artificials" in the surface soils.

Loss on Ignition. Substantial losses were shown in both surface soils and subsoils from all treatments. Complete artificials showed the greatest losses.

Total Nitrogen. Original values in both surface soil and subsoil were high (0.330 and 0.154 per cent. respectively), due no doubt to past history. Appreciable losses were shown in all samples, the least occurring in the farmyard manure plots.

Available Potash. Initial values were low in both surface and subsoil (0.0057 and 0.0053 per cent.). All treatments show higher values for surface soils, complete artificials being highest, but increases for subsoils are only small, suggesting fixation in the surface soils.

Available Phosphoric Acid. Original values were also low (0.0074 and 0.0072 per cent.). Rises due to farmyard manure and complete artificials are considerable, the former showing a higher value than the latter, which is the opposite to the result of potash. There are no appreciable changes in the subsoils the values indicating that all added phosphate has been fixed in the surface soils.

Carbonate of Lime. Only approximate tests were made and these indicated no appreciable changes in lime content during the experiment.

B. RASPBERRIES.

Site and Soil.

This experiment was carried out on the site previously used for

a gooseberry manurial experiment, the results of which were reported in two papers (6, 7). In the former of these the site and soil were described in detail, and hence in this report it is only necessary to recall certain points.

The soil over the area is somewhat variable, the direction of variation running from north-west to south-east, the texture becoming lighter towards the latter point. Soil data in 1921 showed that the supply of available potash was low, and available phosphoric acid only moderate to poor. Nitrogen supplies were then probably fairly good, though not determined, since the land had been broken from old pasture as recently as 1917.

Certain parts of the area tended to lie wet in rainy periods, especially the east half, and attention was given to drainage prior to planting the raspberries. In the gooseberry experiment the lighter eastern section (Plots 9-16) appeared much poorer in potash supply than the western section, and potash omission treatments led to almost complete failure of the bushes.

Plot Layout and Material.

The area is slightly under 1 acre in extent and is divided into 16 strips, running approximately north to south, and each comprising about one-eighteenth of an acre.

The arrangement of the plots was identical with that for the gooseberries. In planting, a single row of canes, variety Lloyd George, was planted down the centre of each strip, and lines of the variety Duke of Cornwall were planted as buffer rows along the margins of the strips parallel to the experimental rows. Planting was carried out on October, 1932, unfortunately during a period of wet weather. The canes after planting were not cut down until the following spring. In the autumn of 1935 the variety Duke of Cornwall in the buffer rows was replaced partly by a Long Ashton seedling variety, and partly by the variety Norfolk Giant.

The canes were planted at approximately 18 inches apart in the rows, and the distance between an experimental row and a buffer row was 9 feet. The wide distance between rows was adopted to prevent suckers from any row running into others adjacent to it.

Manurial Treatments and Management.

The manurial treatments given to the gooseberry plots were continued on the raspberries so that they have been continuous from 1921 to 1937.

The 8 treatments given, which were in duplicate, are as follows :—

TABLE I.
MANURIAL TREATMENTS.

Plot Nos.	Manurial Treatments.
1, 9	No manure.
2, 10	Farmyard manure—10 tons per acre annually.
3, 11	Complete organic manure.—Dried blood, steamed bone flour, sulphate of potash.
4, 12	Complete inorganic manure. Nitrate of soda, superphosphate, sulphate of potash.
5, 13	Complete mixed organic and inorganic manure. } Ingredients as in 3 and 4.
6, 14	As 5 and 13 without nitrogen.
7, 15	As 5 and 13 without phosphorus.
8, 16	As 5 and 13 without potassium.

In all treated plots, except farmyard manure, nitrogen was at the rate of 50 lbs. N per acre, phosphate at 60 lbs. P_2O_5 per acre, and potash at 100 lbs. K_2O per acre.

Management was in accordance with current commercial practice, and routine spraying was carried out against the raspberry beetle.

Weather Conditions.

It is necessary to refer to weather conditions since these were exceptional at times and considerably affected growth and cropping results.

Thus the winter of 1932-33 was very wet and the newly planted canes suffered from soil wetness. A drought followed this in the summer 1933 and these two factors necessitated extensive cane replacements in the autumn of 1933.

Drought conditions during the summer of 1934 markedly affected cane growth and greatly restricted the crop. The following winter was abnormally wet and mild, and was followed by a disastrous May frost in 1935 which destroyed the entire crop. The following winter and the summer of 1936 were excessively wet and made picking very difficult. Finally, the wet winter of 1936-37, following on the wet summer of 1936, resulted in much cane killing over the whole area.

Results and Discussion.

General Growth Characters.

Detailed notes on seasonal growth features were made each year, relating to time of coming into leaf, foliage characters, heights of canes, mortality of canes, incidence of mosaic and defoliation phenomena.

Apart from effects associated with weather conditions, growth throughout the plots, excepting those under potash deficiency and to some extent under nitrogen deficiency, was good, heights averaging about 2 feet 6 inches to 3 feet and the numbers of canes tending to be rather large and to form wide rows.

The amounts of growth on the west and east sections (Blocks A and B respectively) were generally similar, though in B, on the lighter soil, the autumn tints sometimes appeared to be more intense, reflecting the differences in soil conditions.

Potash deficiency was the only factor to produce marked effects on growth, and these have been most in evidence on Plots 8 and 9 where leaf scorch was also most severe.

Effects on growth and leaf tints due to nitrogen omission were only clearly shown from 1936.

The order of vigour assigned to the plots from visual observations on August 4th, 1937, was as follows:—

Order of Vigour (High to Low).

Block A. 3, 5, 4, 2, 7, 6, 1, 8.

Block B. 13, 12, 11, 10, 15, 14, 16, 9.

A considerable amount of mosaic developed on the plots between 1934 and 1936, and at the end of the latter season affected canes were removed so as to keep cropping data on a basis of healthy plants. The distribution of the mosaic attack did not suggest any relationship to the manurial treatments.

Pruning Data.

Pruning weights of canes removed from the plots in cutting out old fruited canes and in thinning new canes were recorded for the seasons 1935-37.

In 1935, three pruning operations were necessary owing to the

failure of the crop from frost, but in the other two seasons only the normal autumn thinning was necessary.

Table II shows the relevant data.

TABLE II.
PRUNING DATA. SHOWING WEIGHTS OF CANES REMOVED—KILOS.

Plot No.	Manurial Treatment.	Canes Removed August 1937.	Total Canes Removed 1935-37.	Totals as % Un-manured.	Order Plots. Highest to Lowest.
Block A.	1 No manure	16.96	55.28	100	7
	2 Farmyard manure ..	25.09	78.22	142	2
	3 Complete organic ..	28.91	75.81	138	3
	4 Complete inorganic ..	28.00	70.45	127	5
	5 Complete mixed organic and inorganic ..	30.45	83.55	153	1
	6 Nitrogen omitted ..	19.65*	55.47	100	6
	7 Phosphorus omitted ..	28.50	75.80	138	3
	8 Potassium omitted ..	15.93	43.68	80	8
		193.49	538.26		
Block B.	9 No manure	10.21	39.51	100	8
	10 Farmyard manure ..	27.95	70.45	175	5
	11 Complete organic ..	24.47	63.32	158	6
	12 Complete inorganic ..	28.35	73.85	185	3
	13 Complete mixed organic and inorganic ..	33.13	94.93	238	1
	14 Nitrogen omitted ..	21.09	73.84	185	3
	15 Phosphorus omitted ..	26.06	80.61	203	2
	16 Potassium omitted ..	16.58	45.98	115	7
		187.84	542.49		

* This weight on low side owing to burning of canes during spraying.

The following points emerge from the data in Table II. The total prunings for the two Blocks A and B are very similar. The response in the two blocks for the various treatments, as measured by the results for the respective "no manure" plots, appear larger in Block B, due to the better growth on the "no manure" plot in Block A where potash deficiency is less acute than on the remainder of the area. The same fact accounts for the apparent superiority of Plot 1 over Plot 8.

As regards the effects of the treatments, the most striking point is the position of the "no manure" and "potash omitted" plots in both series, these being clearly segregated from the remainder.

This result shows that potash deficiency was the chief factor limiting growth on the plots.

Although the values for total canes removed do not indicate nitrogen deficiency as a limiting factor this point is shown in the data for 1937.

Phosphate omission on Plots 7 and 15 is associated with high yields of canes and has not so far proved detrimental.

The highest yields in both blocks are on the "complete mixed organic and inorganic" plots, and the results from farmyard manure are similar to those from the complete fertilizer mixtures.

Cropping Data.

Crops were harvested in the seasons 1934, 1936 and 1937. The data are summarised in Table III. (*See next page*)

There was an 11 per cent. difference in total crop weights between the two blocks, due mainly to higher yields on Plots 1 and 8 than on the comparable Plots 9 and 16.

The increases in the crops in the two blocks, due to the manures, on the whole are similar to those for cane growth, apparently greater responses again occurring in Block B. The "no manure" and "potash omitted" plots again form a group, with yields much below those of the other treatments, and potash is shown to be equally essential for fruiting as for cane growth.

Nitrogen deficiency has not reduced fruiting to the same extent as it has cane growth and, even in 1937 in Block B, the nitrogen omitted plot, No. 14, yielded more heavily than one of the complete fertilizer plots, No. 11.

"Phosphate omitted" plots are again grouped with the complete manure treatments, and on Plot 7 this treatment is associated with the highest total yield of all the plots.

There is no outstanding point regarding the yields for farmyard manure and the various complete fertilizers, and it should be noted that no bad effects have resulted so far from the use of a purely inorganic fertilizer on Plots 4 and 12, where annual dressings of this have been applied since 1921.

TABLE III.
CROPPING DATA—KILOS.

Plot No.	Manurial Treatment.	1937.	Totals for 3 Seasons.	Totals as % of Un-manured.	Order Plots. Highest to Lowest.
1	No manure	35.32	79.69	100	7
2	Farmyard manure ..	55.82	107.07	134	3
3	Complete organic ..	55.09	101.24	126	5
4	Complete inorganic ..	54.48	104.61	131	4
5	Complete mixed organic and inorganic ..	55.70	110.15	138	2
6	Nitrogen omitted ..	50.89	97.47	121	6
7	Phosphorus omitted ..	56.10	112.15	140	1
8	Potassium omitted ..	30.70	75.50	95	8
			787.88		
9	No manure	21.22	50.60	100	8
10	Farmyard manure ..	56.58	102.86	220	1
11	Complete organic ..	42.01	90.32	176	6
12	Complete inorganic ..	50.05	107.23	210	3
13	Complete mixed organic and inorganic ..	48.61	109.99	216	2
14	Nitrogen omitted ..	43.10	98.95	194	4
15	Phosphorus omitted ..	46.34	96.14	188	5
16	Potassium omitted ..	25.48	52.48	102	7
			708.57		

C. STRAWBERRIES.

In view of the serious difficulties experienced in strawberry growing since the war, the manurial programme on this fruit at Long Ashton has been framed with a view to ascertaining how far the prevalent troubles are related to nutrition. Two experiments have been in progress on the Research Station plots since 1924, one in which different systems of manuring available to growers are compared, and another in which various deficiency treatments are being studied. The present report is concerned with the former of these.

The special objects of the trial may be stated as follows :—

- (a) To determine whether good crops of strawberries can be grown at present when liberally supplied with farmyard manure.

- (b) To see how the results of other practicable manurial systems compare with those from farmyard manure.
- (c) To ascertain the effects of the continuous cropping of land with strawberries under various manurial systems.

Site and Soil.

The site is practically level and fairly open, the main protection being by a windbreak on the west side.

The soil belongs to the same Series as that on the black currant plots, but owing to its history differs from the latter in lime status and organic matter. In 1923, prior to the experiment, the surface soil was devoid of free carbonate of lime and not so well supplied with organic matter as the black currant area.

Previous to 1917 the area had been under grass for many years, and from 1917 to 1923 it had been utilised for arable crops.

The soil profile is generally similar to that on the black currant area, but the texture is rather heavier, varying from a light to medium fine sandy loam, and drainage is slower.

Values for available potash and phosphoric acid in the surface and subsoil on the "no manure" plots in 1932 were as follows:—

	<i>Surface.</i>	<i>Subsoil.</i>
Available Potash	0.0126	0.0065
„ Phosphoric Acid ..	0.0227	0.0092

In view of the low lime status of the soil two dressings of ground limestone were given during the experiment, in 1923 at 2 tons per acre and in 1935 at 1 ton per acre.

Drainage was not always satisfactory during the experiment and on certain occasions, after wet periods, sections of the plots suffered from wet conditions.

Plot Layout and Plantings.

The area measures approximately 230 yards by 100 yards and contains 24 manurial plots, each 34 feet by 22 feet 6 inches (approx. $\frac{1}{6}$ acre).

The plots are separated by wide alleyways and are in the form of slightly raised beds to assist the drainage.

The variety used throughout was Royal Sovereign and, in all plantings made, the plants were set out in rows 30 inches apart, with spaces of 18 inches between plants in the rows, each plot containing 9 rows and 207 plants.

In planting, late summer or early autumn (July or August) was aimed at, so as to enable crops to be gathered in their maiden year. Such plantings, however, were not always possible, for various reasons.

During the period under review, April 1924 to July 1937, five plantings were made and the sequence of strawberries has been unbroken, with the single exception that a mustard crop was grown in 1935 between the fourth and fifth plantings.

Plantings were made as follows:—1st—April, 1924; 2nd—July, 1926; 3rd—August, 1929; 4th—August, 1932; 5th—April, 1936.

Manurial Treatments.

Treatment A. *Farmyard Manure* at 20 tons per acre, to be ploughed in previous to planting. No further manuring to be given during three-year period.

Treatment B. *Farmyard Manure* at 10 tons per acre, to be ploughed in as in A. *In addition*, a complete fertilizer to be given each spring as under:—

Sulphate of Ammonia to supply 20 lbs. N per acre.
Superphosphate, 150 lbs. Total Phosphate (*i.e.* 75 lbs. P_2O_5) per acre.
Sulphate of Potash, 50 lbs. K_2O per acre.

Treatment C. *Shoddy* (on basis of 5 per cent. Total Nitrogen), at the rate of 2 tons per acre to be ploughed in as in A. *In addition*, to be given each spring as under:—

Steamed Bone Flour, 150 lbs. Total Phosphate per acre.
Sulphate of Potash, 50 lbs. K_2O per acre.

Treatment D. “*Complete Organic*” manure (non-bulky), to be applied each spring as under:—

Dried Blood, 40 lbs. N. per acre.
Steamed Bone Flour, 150 lbs. Total Phosphate per acre.
Sulphate of Potash, 50 lbs. K_2O per acre.

Treatment E. “ *Complete Inorganic* ” manure, to be applied each spring as under :—

Sulphate of Ammonia, 40 lbs. N per acre.

Superphosphate, 150 lbs. Total Phosphate per acre.

Sulphate of Potash, 50 lbs. K_2O per acre.

Treatment F. “ *Organic Manure*,” containing N and P_2O_5 , but no potash, to be given each spring :—

Dried Blood, 40 lbs. N per acre.

Steamed Bone Flour, 150 lbs. Total Phosphate per acre.

Treatment G. *Farmyard Manure* at rate of 12 tons per acre, to be ploughed in previous to planting.

Farmyard Manure at rate of 8 tons per acre, to be spread on the surface in March, following the taking of the first crop.

Treatment H. *Control Plot.* No manure to be given throughout the period of the experiment.

This scheme was followed until the spring of 1936, when the 5th planting was made. At that time the following alterations were made for use in 1936 and subsequent seasons.

1. Rates for nitrogen, phosphate and potash were altered to the following equivalents, *vice* 40 lbs. N, 150 lbs. Total Phosphate and 50 lbs. K_2O per acre :—

Nitrogen equivalent to 3 cwt. Nitro-chalk per acre.

Phosphate „ „ 4 „ Superphosphate per acre.

Potash „ „ 2 „ Sulphate of Potash per acre.

2. Nitro-chalk was substituted for Sulphate of Ammonia.
3. The rates for N, P, K in the artificials in Treatment B were at half the rates used in Treatment E. Previously only N had been used at the half rate in Treatment E.

The spring applications of fertilizers were made each season during early March, great care being taken to ensure even distribution.

Management.

Cultivation has been more detailed than in commercial practice, and every effort made to control weeds without removing them from the plots. Hand labour was mainly used.

Between plantings the plots were ploughed and well harrowed, and were subsoiled in 1932 and 1935.

The plots were strawed each season prior to picking. Routine spraying was not practised but prompt measures were always taken to deal with pests and diseases as they appeared.

Results and Discussion.

Very detailed records were collected throughout the experiment. They related to general growth characters, vigour of the plants, incidence of pests and diseases, dying out of plants, crop yields and quality of the fruit.

In recording data concerning growth characters, vigour and dying out of plants, careful examinations were made (1) in early spring, (2) just prior to cropping, (3) immediately subsequent to picking and (4) in late autumn, in order to relate the observations to special seasonal conditions.

Quantitative data on dying out were obtained by recording the numbers of missing plants and vigour was assessed by a system of pointing.

General Growth Characters.

Growth characters were regarded as supplementary to quantitative vigour marking. It was found that the critical period for comparison of growth characters was shortly after picking, in July, when the plants were feeling the drain of recently gathered crops. At this time the plants on all plots usually showed much purple tinting of the foliage, and this was generally strongly marked on the weaker plants. Marginal leaf scorch was the only other symptom of note, and the "omit potash" and "no manure" plots could often be differentiated from the other plots by means of this. The "no manure" plots also tended to show rather pale foliage. The foliage on the farmyard manure plots was comparatively luxuriant and these plots could generally be located by casual inspection.

Causes noted as determining low vigour were: soil wetness which caused dwarfing and dying out, especially in 1924, late 1932, 1933 and 1937; frost which killed many plants shortly after planting in spring 1936; "Red Plant" which was severe in the

1st planting, and which occurred to appreciable extents in the 3rd and 4th plantings; "Yellow Edge" which proved disastrous in the 2nd planting; and Tarsonemid Mite, which, in the 4th planting, caused serious stunting in 1933 and 1934, with subsequent failure of the plants in the spring of 1935.

Vigour.

Vigour was recorded quantitatively on thirty-three occasions during the experiment by assigning values ranging from 4 to 0 on the following basis:—4 very vigorous, 3 vigorous, 2 moderate vigour, 1 poor vigour, 0 total failure.

The records are summarised in Table I.

TABLE I.
VIGOUR MARKINGS. MEAN VALUES PER PLOT FOR EACH PLANTING.

Treat- ment.	Planting.					Totals and Order of Vigour for Treatments.
	1st	2nd	3rd	4th	5th	
A	3.5	2.9	3.3	3.1	3.5	16.3 (1)
B	3.1	2.7	3.6	3.0	3.8	16.2 (2)
C	2.2	2.1	3.2	3.0	2.7	12.2 (5)
D	2.6	2.0	3.1	2.6	2.4	12.7 (6)
E	2.4	2.4	3.2	2.8	2.8	13.6 (4)
F	2.0	1.9	2.7	2.4	2.7	11.7 (7)
G	2.7	2.9	3.4	2.8	3.7	15.5 (3)
H	1.7	2.1	2.6	2.3	2.6	11.3 (8)
Totals	20.2	19.0	25.1	22.0	24.2	—

The data show that the farmyard manure plots (A, B and G) were the most vigorous; those receiving complete organic (shoddy, C) and complete artificials (E) were similar in vigour, being intermediate in vigour between farmyard manure and complete organic (blood, D); plants under the treatments "potash omitted" (F) and "no manure" (H) were definitely the least vigorous.

Points relating to vigour in the various plantings were as follows:

1st Planting.—Vigour was never satisfactory, possibly mainly due to conditions at planting and to disease.

2nd Planting.—The plants showed progressive deterioration due to Yellow Edge disease, and by May, 1929, could be regarded as failures.

3rd Planting.—This was the most successful planting, and vigour was well maintained.

4th Planting.—Vigour was poor in the early stages due to wet soil conditions after planting, and in the 2nd and 3rd years Tarsonemid Mite caused relative failure.

5th Planting.—Vigour was seriously affected by frosts soon after planting and later by wet winter conditions.

Casualties.

The numbers of casualties were often considerable and differed greatly in the different plantings. They were not related to the manurial treatments but were caused by wet soil conditions, frost, and diseases and pests, particularly Yellow Edge, Tarsonemid Mite and Red Plant.

Crop Yields.

Crop yields were obtained for ten seasons between 1925 and 1937 inclusive, no crops being harvested in 1933, 1935 and 1936. On all occasions, "total" and "marketable" weights were recorded, the differences between the two categories being due to such causes as birds, Mildew, malformed fruits. In all treatments "marketable" fruits comprised approximately 80 per cent. of the total crops. The results for total yields are summarised in Table II.

TABLE II.
CROP YIELDS (KILOS).

Treatments.	Total Yields 10 Seasons.	Totals as % of No Manure. Plot.	Significance of increases due to Manuring.
A. 20 tons farmyard manure ..	1054	136	Significant to 1%
B. 10 tons farmyard manure + artificials	1056	136	do.
C. Complete organic (Shoddy) ..	890	115	do.
D. Complete organic (Dried Blood)	802	103	Not significant
E. Complete inorganic	876	113	Significant to 5%
F. Complete organic (Dried Blood) less potash ..	795	102	Not significant
G. 12 + 8 tons farmyard manure	1018	131	Significant to 1%
H. No manure	777	100	

The data show that all the treatments excepting "complete organic" (dried blood) D, and that treatment but omitting potash F, gave significant increases in yields, treatments A, B, C and G to the highly significant 1 per cent. point, and treatment E to the 5 per cent. point. The yields under all the farmyard manure treatments were similar and were significantly higher than for the shoddy treatment. The latter treatment and the "complete artificials" were not significantly different. The results for treatments D and F suggest that dried blood is not an effective source of nitrogen for strawberries, and because of this the effect of potash omission could not be assessed. The detailed records also showed that none of the treatments affected the time of harvesting of the crops.

Data for Mustard.

A mustard crop was grown on the plots in 1935 after ploughing-in the 4th planting, with a view to examining the behaviour of this crop under the various treatments. Yields were measured by cutting the plants when they were just coming into flower and weighing the produce from four areas, each 1 square metre, on each plot. The results are summarised in Table III.

TABLE III.
COMPARATIVE CROP YIELDS FOR MUSTARD
(Kilos per 12 sq. metres).

	A.	B.	C.	D.	E.	F.	G.	H.
Yields in Kilos. .	21.08	22.64	18.57	22.97	23.12	21.82	22.71	14.07
As % "No Manure"	150	161	132	163	164	155	161	100
Order of Treat- ments ..	6	3	7	2	1	5	3	8

The results were not parallel with those for the strawberry crops but appeared rather to reflect the availability of nitrogen in the soil. Thus all plots receiving a nitrogenous dressing in a complete manure in spring 1935, viz. E, D and B, are in a group showing high yields. Treatment G is also in this group, and since this plot receives the same amount of farmyard manure as in treatment A, but in two applications instead of one, it would seem that the former method ensures a steadier level of nitrogen over the three-year period given to each planting of strawberries.

The high yield for treatment D, where dried blood is used, is of interest since, for strawberries, this treatment gave poor results.

Shoddy showed much the lowest yield, and next, farmyard manure at 20 tons previous to planting, and it would appear that under these treatments nitrogen availability at the end of the three-year period is relatively low. Comparison of treatments D and F suggests that, even with mustard, potash omission is possibly of importance on this soil.

CONCLUSIONS.

A. Black Currants.

1. Potash deficiency was the chief factor limiting growth at the beginning of the experiment. The deficiency was completely remedied after three or four seasons by the potash and farmyard manure treatments given.

2. Pruning weights were significantly increased by farmyard manure treatment and to almost a significant extent by complete artificials, but not by treatments where nitrogen, phosphate or potash were omitted from the complete fertilizer.

3. In spite of frost effects on cropping, significant increases resulted from the treatments farmyard manure and complete artificials, but not from the other treatments.

4. The results for prunings and crops suggest that farmyard manure treatment produced the greatest effects, followed by complete artificials, and that nitrogen, phosphate and potash, especially the last, were limiting factors where omitted from the complete artificial fertilizer.

5. Potash deficiency was associated with decreased susceptibility to *Pseudopeziza Ribis*, whilst deficiencies of nitrogen and phosphate appeared to increase susceptibility to attacks of the fungus. Farmyard manure also seemed to decrease susceptibility.

6. All the manurial treatments resulted in losses in organic matter (loss on ignition) and total nitrogen from surface soils and subsoils over the period of the experiment, the losses being least on the farmyard manure plots.

Available potash and phosphoric acid were increased in the surface soils by both farmyard manure and complete artificials, the increases of potash being higher for complete artificials and of phosphoric acid for farmyard manure.

Considerable fixation of added potash and phosphoric acid by the surface soils occurred.

B. Raspberries.

1. Cane growth, as measured by prunings of fruited canes and thinnings of young canes, was greatly restricted by potash deficiency throughout the experiment, and somewhat restricted by nitrogen deficiency in the later stages.

2. Potash deficiency was also the chief limiting factor to cropping, but nitrogen deficiency did not appear to affect cropping to any appreciable extent.

3. Farmyard manure and complete organic and inorganic fertilizers gave similar increases, and phosphate deficiency did not adversely affect cane growth or cropping.

C. Strawberries.

1. The manurial treatments produced significant effects on growth and cropping, the effects of farmyard manure treatments being outstanding in both cases.

2. Highly significant increases in yields resulted from farmyard manure treatments and from the complete organic manure containing shoddy. The increase was rather smaller from a complete artificial fertilizer. Dried blood appeared ineffective as a source of nitrogen for strawberries. Manuring did not affect the ripening season or the proportions of marketable fruits in the total crops.

3. Vigour and cropping were also greatly affected by the following factors: soil wetness, especially in winter; frost immediately after planting; weak runners; Red Plant and Yellow Edge diseases and Tarsonemid Mite.

4. The incidence and effects of the diseases and pests were not correlated with the various manurial treatments.

5. The growth of a mustard crop at the end of a three-year cropping period showed that yields of this crop were mainly determined by supplies of available nitrogen, and did not parallel those of the strawberries. The yields indicated that where farmyard manure or shoddy were applied at the beginning of a three-year period, available nitrogen was low at the end of the period.

SUMMARY.

1. Abridged accounts are given of three manurial experiments on black currants, raspberries and strawberries, carried out at Long Ashton during the period 1924-1937.

2. Significant effects from various manurial treatments are shown in each case.

In particular it is shown that farmyard manure is of great importance for black currants and strawberries; potash deficiency appeared the primary limiting factor for raspberries and black currants, and was possibly of importance for strawberries; nitrogen and phosphate deficiencies were both important for black currants, and the former also affected cane growth significantly but not cropping in the case of raspberries.

3. The incidence of *Pseudopeziza Ribis* on black currants was shown to be influenced by deficiencies of potash (decreased), and of nitrogen and phosphate (both increased). The strawberry diseases, Yellow Edge, Red Plant and Tarsonemid Mite, were not influenced by manuring.

REFERENCES.

- (1) KNIGHT, L. D. M. and WALLACE, T. "The Effects of Various Manurial Treatments on the Chemical Composition of Strawberries." *J. Pomol. and Hort. Sc.*, Vol. X, p. 147 (1932).
- (2) OSMOND, D. A. "A Survey of the Soils of the Long Ashton Research Station." *Ann. Rept. Long Ashton Res. Sta.*, p. 256 (1936).
- (3) WALLACE, T. "A Field Experiment on the Manuring of Black Currants." *J. Pomol. and Hort. Sc.* XVI, p. 127 (1938).
- (4) WALLACE, T. "A Field Experiment on the Manuring of Raspberries." *Ibid.*, XVI, p. 3 (1938).
- (5) WALLACE, T. and VAIDYA, V. G. "A Field Experiment on the Manuring of Strawberries." *Ibid.* XVI, p. 148 (1938).
- (6) WALLACE, T. "Field Experiment on the Manuring of Gooseberry Bushes." *Ibid.* VI, p. 184 (1927).
- (7) WALLACE, T. "The Effects of Manurial Treatments on the Chemical Composition of Gooseberry Bushes." *Ibid.* VII, p. 130 (1928).

APPLE ROOT-STOCK INVESTIGATIONS.

PROGRESS REPORT.

By G. T. SPINKS.

Introduction.

In the Annual Report of this Station for 1930 an account was given of the earlier stages of an investigation into certain apple root-stocks. Examination of a large number of seedling stocks in previous years had led to an attempt to classify these stocks on a basis of root morphology. At the same time, attempts were made to propagate by vegetative means representatives of the various classes, and eventually clones derived from 15 different seedlings were propagated by layering and were used as root-stocks in a series of trials.

By 1930, the examination of numerous trees when lifted from the nursery at two to five years of age had led to the conclusion that the morphological differences on which the classification of the original seedlings were based did not persist in older clone plants derived from those seedlings. The prospect of finding any correlation between tree performance and the original seedling classification therefore appeared to be remote and the main purpose of the trials which had been established was henceforward considered to be the comparison of the influence on tree performance of the various individual clone stocks. As several different varieties were used as scions, and as trials were being carried out under differing conditions of soil, climate and management, it was hoped to discover whether any of the new clone root-stocks were improvements on previously known stocks.

The first trial plot was planted in December, 1926, and other plots were established in succeeding years up to the end of 1934, so that a series of plots of various ages is now in existence. Some of the younger plots are barely well established yet and have yielded no information with regard to blossom or crop, but a few of the older plantations have borne crops for a number of years. A detailed account of results obtained in the older trial plots will shortly be prepared, but meanwhile the following brief summary gives a general indication of the performance of the various stocks up to the present time.

Experimental.

Some of the trials under review are being carried out at Long Ashton, while others are at outside centres. On some plots the trees are being grown in the form of bushes, on others as standards; in some cases the trees are being grown in grass. The plots vary in design and differ from one another in the numbers of trees on the individual stocks.

None of the above particulars are given in the present report and no actual figures are presented, but the relative effects of the various stocks are indicated. Size of tree and crop weight are the only data considered and are dealt with under separate headings below. The diameter of the trunk of the tree has been used as the criterion of tree size in the present instance, though this is not quite consistently correlated with other measurements, such as height.

The results found with certain scion varieties have been grouped together and for each trial plot the relative performance of each stock is shown by arranging the stocks in a decreasing order of magnitude. Thus, in any one list, the first stock named has been associated with the largest trees or the heaviest crops, as the case may be, while the last on the list indicates the smallest trees or lightest crops. At this stage no attempt has been made to indicate the significance of the differences.

The series of stocks under trial are identified by the symbols A3, A8, A9, A10, B2, D1, E7, E8, F2, F10, F11, F12, G6, G7 and G8, while II and XII indicate two well-known types of East Malling stocks. One or both of the last-named stocks were included in every trial for purposes of comparison. Very few trial plots include a complete range of stocks, and in the following section a complete list of the stocks in each particular trial is usually given, but in a few cases the stocks occupying the middle part of the list are omitted.

The figure, *e.g.* 10 years, given for each plot indicates the number of years which have elapsed since the trees were planted in the trial plot. Bush trees were usually two years old, and standards four years old, at the time of planting.

Results.

Tree Size (trunk diameter).

Worcester Pearmain.

Plot 16, bush, 12 years.

XII, B2, G8, II, A3, F12, E7, E8, A8, F2, A10, A9, D1.

Plot 21, standard, 10 years.

XII, E7, G7, F10, F11, D1.

Plot 22, standard, 10 years, grass.

G8, G7, E7, G6, F12.

Plot 22, standard, 10 years, grass (2nd series).

G8, E7, F11, F10, G7, F2, G6.

Plot E, standard, 10 years, grass.

G8, E7, G7, F12, G6.

Plot W, bush, 9 years.

B2, A3, E8, A10, F12, D1.

Plot K, bush, 8 years.

XII, G8, E7, ———F12, D1.

Plot T, bush, 8 years.

XII, G8, E7, ———A10, F12.

James Grieve.

Plot 16, bush, 12 years.

II, A9, A3, E8, E7, B2, A8, F2, F12, A10, D1.

Lane's Prince Albert.

Plot 16, bush, 10 years.

II, XII, G7, E7, ———D1, A10.

Bramley's Seedling.

Plot 22, standard, 10 years, grass.

G8, E7, G6, F2, F11, F10.

Plot B, standard, 7 years, grass.

G8, G7, E7, F11, G6.

Plot D, standard, 7 years, grass.

G8, E7, XIII, ———.

Plot PE, standard, 6 years, grass.

XII, E7, ———G6, B2.

Plot PI (2), standard, 6 years, grass.

G8, XII, D1 ———.

Plot R, standard, 6 years, grass.

XII, G7, G6.

Newton Wonder.

Plot 21, standard, 10 years.

XII, D1, G8, G7, E7, F12, G6, F11.

Plot SA, standard, 8 years, grass.

D1, G8, F10, F12.

Plot ST, standard, 8 years, grass.

XII, E7, G7, G6.

Blenheim Orange.

Plot 21, standard, 10 years.

XII, G8, G6, F10, G7, E7, D1, F12, F11.

Kingston Black.

Plot PI (1), standard, 10 years, grass.

G8, E7, G7.

An examination of the above lists shows that stock XII is included in eleven series of trials and that in nine of these it occupies first place in the order of size of tree, while in the remaining two cases it is placed second. Thus under many different conditions, and in combination with several scion varieties, this stock has been found to produce larger trees than any of the Long Ashton clone stocks.

Among the new stocks under trial, G8 has fairly consistently produced the largest trees, and the trees on this stock are often only slightly smaller than those on XII. Other stocks which frequently occur near the head of the list are E7 and G7. Several others such as A3, B2, and II have occasionally been associated with large trees, but not consistently.

Small trees have usually resulted as the use of F12 as a stock and sometimes owing to the use of G6. In some cases where anomalous results have been obtained it is not yet certain how far scion-rooting is responsible. In more recent trials trees have been planted with the union well above the surface of the soil, but in some of the earlier trials the union was placed one inch below the surface and it now appears that scion-rooting has taken place in some cases even at that depth.

The stocks A10 and D1 are of particular interest, as they appear to be very largely incompatible with Worcester Pearmain, James Grieve and Lane's Prince Albert, and all these stock-scion combinations have produced much-dwarfed and unhealthy trees. In every case where trees have been more successful this has been found to be due to scion-rooting. The stock D1, however, has been used in a few trials in combination with Bramley's Seedling, Newton Wonder and Blenheim Orange with very different results. Though Blenheim Orange trees on this stock are of only medium size the other two varieties have produced large trees comparable

to those on XII and G8, and there appears to be no incompatibility between D1 and these three scion varieties. It appears unlikely that these favourable results are due to scion-rooting, though the possibility of this has not yet been fully investigated.

The remainder of the stocks under trial, of which no special mention has been made above, have been associated with trees of moderate size and have not shown any tendency to produce either large or small trees.

Crop Weight.

Worcester Pearmain.

Plot 16, bush, 12 years.

II, G8, E7, E8, XII, F12, A8, A3, B2, F2, A10, A9, D1.

Plot 21, standard, 10 years.

XII, E7, F10, D1, G7, F11.

Plot 22, standard, 10 years, grass.

E7, G7, G8, G6, F12.

Plot 22, standard, 10 years, grass (2nd series).

F11, G8, G7, E7, F10, G6, F2.

Plot E, standard, 10 years, grass.

E7, G7, G8, G6, F12.

Plot W, bush, 9 years.

A10, D1, E8, A3, B2, F12.

Plot K, bush, 8 years.

G7, G8, E7, II, ——— XII, D1, A9,

Plot T, bush, 8 years.

E7, II F11, G7, ——— A10, F12.

James Grieve.

Plot 16, bush, 12 years.

II, E7, E8, A3, F2, F12, A8, A9, A10, D1.

Lane's Prince Albert.

Plot 16, bush, 10 years.

II, G7, F11, G8, ——— F12, XII, D1, A8, A9.

Bramley's Seedling.

Plot 22, standard, 10 years, grass.

E7, G8, F11, G7, F10, G6, F2.

Plot B, standard, 7 years, grass.

E7, ———.

Newton Wonder.

Plot 21, standard, 10 years.

G7, E7, D1, F12, F11, G8, G6, XII.

Blenheim Orange.

Plot 21, standard, 10 years.

E7, F11, G7, F10, G8, D1, F12, G6, XII.

Kingston Black.

Plot PI (1), standard, 10 years, grass.

E7, G7, G8.

It is obvious that many of the trial plots, especially those consisting of standard trees, are not yet of an age to have yielded much information on the cropping capacity of the trees. The very severe frost damage experienced in many of the plots in 1935 and 1938 has also reduced the information on crop weights which is available up to date. Some of the plots included in the particulars about tree size are not mentioned under the heading of crop weight, as they have not yet borne crops which can be considered of any significance.

On a number of plots, crops of appreciable size have been borne in one or two years, and while these crops cannot be said to give much information as regards the ultimate cropping capacities of trees on various root-stocks, they do provide some indication of the root-stocks which favour the cropping of trees at a fairly early age.

From the above list it is seen that the most consistently heavy croppers up to the present time have been trees on stocks E7 and II, though it is not clear which of these two has given the better results. Other stocks which have favoured the production of good crops on fairly young trees include G7, G8, F11 and E8. Poor crops from young trees have been associated with stocks A9, A10, D1, F12, and usually XII. It is noticeable, however, that in one trial, standard Worcesters on XII have cropped well at a comparatively early age, and on other plots the crops on XII are becoming relatively larger as the trees grow older.

The bush trees of Worcester and Grieve on Plot 16, which were the first to be planted out as a trial, have supplied the largest number of crops and the records show that the relative productiveness of the different stocks has varied very little during the last few years. Even six years ago II, E7, G8 and E8 were at the head of the list for crop, while A9, A10 and D1 were at the bottom.

Heavy crops seem to be correlated with abundant blossom production, though the amount of fruit is also affected by the percentage set of the blossom, which appears to be influenced by the root-stock. The percentage set of trees on II, for instance, is usually high compared with that of trees on some other stocks.

Conclusions.

A general consideration of the stock effects found in the trials up to the present time suggests that G8, E7, and E8 are the stocks of the Long Ashton series which are most likely to be found of value. Under some circumstances G8 produces a large tree which also begins to crop earlier than trees on XII. Trees on E7 crop well and are fairly vigorous, while E8 appears to favour heavy cropping and a semi-dwarfing effect. Though these stocks have given satisfactory results, experiences to date do not indicate that they are definitely superior to stocks such as II and XII.

Tests carried out by Dr. H. G. H. Kearns have shown that none of the stocks under trial are immune to the attacks of Woolly Aphis.

Summary.

A series of 15 clone apple root-stocks, originally obtained from selected seedlings, were propagated by layering and worked with Worcester Pearmain, James Grieve, Lane's Prince Albert, Bramley's Seedling, Newton Wonder, Blenheim Orange and Kingston Black.

A number of trial plots containing the various root-scion combinations have been planted during the last twelve years: these include trials of bush and standard trees in cultivated ground and grass.

Records of tree size show that the stock XII is associated with the largest trees, while G8, E7, and G7 have also produced large trees. Small trees have resulted from the use of F12 and G6, and sometimes of A10 and D1. A10 and D1 are apparently incompatible with certain scions, but D1 appears to be fully compatible with others.

Stocks associated with heavy crops include II, E7, G7, G8 and E8, but poor crops have been borne by trees on A9, A10, D1 and F12.

Of the new clone stocks under trial G8, E7 and E8 appear at present to be those which are most likely to be of value, but further comparative trials with such stocks as II and XII are required.

PROGRESS REPORT ON FRUIT BREEDING.

By G. T. SPINKS.

During the four years which have elapsed since the publication of the last progress report very few new seedlings have been raised and work has been mainly confined to the observation, selection and propagation of existing seedlings. In 1935 and 1938 the severe spring frosts resulted in very poor crops, especially on the top fruits, but good crops were borne in 1936 and 1937.

Apples.

The Annual Report for 1936 contained a paper dealing with the inheritance of various characters in a number of families of seedlings. With the exception of a few seedlings which have been propagated, all these older families have now been discarded and the more recent observations deal with families which started bearing in 1934 or later.

Crops were obtained from 120 seedlings in 1936 and from 180 in 1937. The majority of these trees are included in families in which one of the parents is Worcester, Cox or McIntosh Red. The publication of a complete account of these families will be deferred until all the trees have cropped, but the following notes provide a summary of the observations made up to date.

Crosses between McIntosh Red and Worcester, James Grieve or Cox have been notable for the large proportion of the seedlings which have been badly infected by canker and a large number of trees have been so badly attacked that they have been discarded before they have fruited. There seems to be a distinct tendency for the flavour and flesh characters of McIntosh Red to be inherited. In the cross with Worcester much of the fruit has been deeply coloured with red, though often dull and unattractive in appearance, but in the other families colour has been less abundant.

Worcester, when crossed with Devonshire Quarrenden, Beauty of Bath, Charles Ross or Rival, has produced a good number of highly-coloured fruits, especially in the first two families, but flavour is seldom better than moderate. Fruit ripening in August has been commonly found in the cross between Worcester and Beauty of Bath.

Cox $\times$ Rival and Cox $\times$ Beauty of Bath have produced few seedlings with any outstanding characters. The seedlings of Court Pendu Plat crossed with American Mother and Charles Ross are notable chiefly for the tough flesh of the fruits and sometimes for the late season of ripening.

From the above families, 10 seedlings have so far been considered worthy of further attention and 7 of these have been propagated. Several seedlings selected and propagated in former years have now been discarded, as in various respects they fall short of the standard required of a new variety.

The new, named varieties Taunton Cross, Worcester Cross, Hereford Cross, Gloucester Cross and Newport Cross are still under trial at Long Ashton and a number of other centres. Of these sorts the first three seem to be the most successful, Gloucester Cross being slow in coming into bearing, while Newport Cross is very similar to Hereford Cross but inferior in flavour. All the above varieties have cropped well in the plantations of the Somerset Farm Institute at Cannington and have produced highly-coloured and attractive fruit. These varieties have been distributed to a few fruit growers and nurserymen but very few reports on their value have yet been received. A few opinions on Taunton Cross, however, are distinctly favourable and one large grower is giving it a trial on a fairly extensive scale.

Pears.

The three large families of seedlings planted out in 1935 have not yet come into bearing, only three trees carrying a crop in 1938. Comparatively few trees of older families now remain and the greatest number of these to fruit was 40, in 1935. Records from these families were dealt with in an article on Pear Breeding in the Annual Report for 1937 and most of the trees have now been discarded. A number of seedlings of the family Comice $\times$ Conference are still under observation, however, and 8 of these appear to be worthy of further attention. Two selected seedlings have been propagated during the last four years.

Several selected varieties which have been under trial have now been discarded, some because they ripen from the core outwards and others because they fail to ripen satisfactorily however long they are kept, but other selections are receiving a longer trial as they still show considerable promise. The named variety, Bristol Cross, which is still satisfactory at Long Ashton, has been distributed, but few growers have yet pronounced an opinion on it: one nurseryman, however, has been propagating it in large numbers.

Plums.

Fruit was borne on 50 seedlings in 1937, but on smaller numbers in 1936. Most of these are included in families obtained by crossing Giant Prune with Coe's Golden Drop, Jefferson and Victoria respectively, while another fairly large family is derived from Jefferson $\times$ Purple Pershore. The first-named family has produced a large proportion of good fruits, most of which show a considerable resemblance to Coe's Golden Drop in shape, sweetness and lateness of season. Though the quality of the fruit varies, six seedlings of this family seem good enough to be retained for further observation but none of these have yet been propagated. Several other seedlings from this cross were propagated in earlier years and are proving satisfactory. The other families mentioned above have produced few seedlings of any possible value.

New named varieties still under trial include Severn Cross, a late dessert plum similar to Coe, and Wye Cross, a late blue cooking plum. Both these have cropped well, are of satisfactory quality, and their lateness seems to be an asset, but both appear to be somewhat susceptible to "silver-leaf." Wye Cross is one of the few varieties which carried a crop after the frost of 1938.

Avon Cross is a good quality, late dessert plum, but usually suffers from the attacks of wasps long before the fruit is ripe. Teme Cross has been disappointing, being a very shy bearer, and it now seems doubtful whether there is any future for it.

There has been little demand for any of these varieties and estimates of their value have been obtained almost entirely from experiences at Long Ashton. One grower, however, has reported favourably on Severn Cross.

Black Currants.

At the end of 1936 the bushes in a large trial plot of seedling varieties were grubbed, after bearing their seventh crop, as the land was needed for other purposes. This plot contained 43 seedling varieties, Boskoop and two strains of Baldwin, there being in most cases 72 bushes of each variety, divided into three units in different parts of the plot. The great majority of the varieties were discarded at the conclusion of the trial on account of poor cropping capacity or other defects, but 9 varieties were retained for a further trial.

Two varieties were named and the total crop weights per bush

of these over the seven year period are compared with those of Baldwin and Boskoop below. Relative weights are given, the crop of Baldwin being taken as 100.

Baldwin (Herefordshire strain)	..	100
Boskoop		82
Mendip Cross		139
Cotswold Cross		155

Mendip Cross and Cotswold Cross are similar in season to Boskoop and Baldwin respectively. The average annual crop per bush of Cotswold Cross was 3.6 pounds, including the first year, when the crop was naturally small, and 1935, a year of frost damage. The best crop per bush of this variety was 7.0 pounds in 1934.

Eight of the nine varieties retained for further trial were planted in a trial in February 1934 and up to the present their performance has confirmed the results obtained from the first trial. This plot, however, includes no standard varieties as controls. One un-named variety has attracted attention on account of the firmness of the berries and ease of "strigging": as this variety crops well it may be of value. Four other sorts are no longer thought to be worth further trial.

The two named varieties have been fairly widely distributed and reports on them have been received from a number of sources. Favourable opinions of Mendip Cross have been obtained from growers in parts of Somerset, Hereford, Hampshire and Suffolk, though the variety has not been uniformly successful. Cotswold Cross also has proved to be very satisfactory in some places but less so in others. It is interesting to find that, of growers who have both varieties, some consider Mendip Cross to be the better variety while others favour Cotswold Cross. It seems evident that local conditions affect the success of these two currants, as they do that of other varieties. On the whole, reports indicate that, under suitable conditions, both varieties are useful additions to the range of commercial varieties.

Raspberries.

In 1934 and 1935 seedlings to the number of 13 were selected from a family produced by crossing Viking and Preussen. Clones propagated from these plants have been kept under observation, but up to the present they have been disappointing. Most of the varieties have produced canes which are strong but few in number, and crops have not been good. Fruit is large, bright and sweet,

but perhaps too soft, and is much attacked by birds. These varieties, however, will receive a further trial for a year or two.

In addition to the above, 19 other seedling varieties from older families are still under trial on a small scale, but have not yet yielded much information owing to the frost in 1938. A variety which appeared promising some years ago has become infected with "mosaic," but an attempt is being made to obtain a clean stock of this clone with a view to further trial.

A variety selected a few years ago from the family Lloyd George $\times$ Improved Beehive now appears to be the best seedling sort under trial. It is a good grower and bears heavy crops of large berries. It is being propagated and will be tested more extensively.

Blackberries.

In 1936 flowers of the Veitchberry were fertilized with pollen from the Black Diamond blackberry. A good set of fruit was obtained, and from the resulting seeds about 300 seedlings were obtained and planted out in 1937, but owing to unfavourable weather conditions many of these died. The surviving plants have not yet fruited. The reciprocal cross was attempted, but the pollen of the Veitchberry was very poor and only a few scattered drupelets developed on the pollinated blossoms.

With the above exceptions, work with blackberries has consisted of cropping trials of the variety Ashton Cross and three other seedling sorts in comparison with Himalaya and Black Diamond. During the nine years 1930—1938 the mean annual yields per plant were :—

Himalaya	..	..	..	..	15.1 lbs.
Ashton Cross	..	..	..	..	22.3 ..

During 1934-38 the mean annual yields per plant for the above and also for younger plants of Black Diamond and Ashton Cross were :—

Himalaya	..	..	..	..	14.3 lbs.
Ashton Cross (older)	..	..	..	..	20.2 „
Black Diamond	..	..	..	..	20.6 „
Ashton Cross (younger)	..	..	..	..	15.2 ..

No real significance can be claimed for the above figures, as the plot was not laid out as a proper cropping trial and the number of plants recorded was rather small (20 or less in each series). The

figures suggest, however, that Black Diamond is a heavier cropper than Himalaya, though no pomological differences between these varieties have been detected, and that Ashton Cross may, in some positions, crop as heavily as Black Diamond. The above figures do not always indicate the total crop, as in some years considerable quantities of berries were left unpicked when prices fell at the end of the season. The proper development and ripening of blackberries seems to be largely affected by weather conditions and in some years the weight of crop picked, on all varieties, was much less than had been anticipated.

Samples of Ashton Cross have been equal to those of Black Diamond in size and appearance, while the flavour of Ashton Cross is definitely superior. On the other hand, Ashton Cross is possibly more affected by weather conditions. Observations at Long Ashton and reports from growers in other districts suggest that this variety does best in a fairly wet climate, as it has been less successful at Long Ashton in dry years and also in other places where rainfall is lower.

Strawberries.

In 1935 two families of seedlings were raised by crossing seedlings produced and selected in previous years: each family included about 900 plants. In one family one of the parents was a pistillate variety, the flowers bearing no stamens, and it has been found that approximately 50% of the resulting seedlings show the same character. A similar result has been found in the past whenever a pistillate variety has been used as a parent.

The above seedlings are mainly very vigorous plants and up to the present few have shown signs of attack by virus diseases. They have now fruited for two years, and in many cases crops have been heavy and the fruit of good quality, though in one family it tends to be soft: none of the plants are very early in season. Runners have been taken from 60 plants in order to raise small clones for further trial.

Other seedling varieties have been under trial for several years, but circumstances have prevented their receiving a really satisfactory trial. A number have been discarded as unsatisfactory, but about 20 varieties have been retained, though some of these have been grown only in small quantities. One of the best sorts has shown cases of "yellow edge," but an attempt is being made to keep a clean stock. Several promising varieties are of the *Chiloensis* type and seem to be resistant to this disease, but it is not known whether they act as carriers of the disease.

Summary.

During the last four years families of seedling apples, pears, plums, black currants, raspberries and strawberries, have been under observation: the characters of the seedlings have been noted and compared with those of the parent varieties.

A small number of seedlings of each sort of fruit have been selected for propagation and further trial.

The trial of seedling varieties propagated in previous years has been continued. These include the following named varieties which are being grown at a number of centres in addition to Long Ashton:—

Apples	..	..	..	Gloucester Cross, Hereford Cross, Newport Cross, Taunton Cross, Worcester Cross.
Pears	..	..	..	Bristol Cross.
Plums	..	..	..	Avon Cross, Severn Cross, Wye Cross.
Black Currants	..	..	..	Cotswold Cross, Mendip Cross.
Blackberries	..	..	..	Ashton Cross.

FROST DAMAGE AT LONG ASHTON IN 1938.

By G. T. SPINKS and G. E. CLOTHIER.

The spring frosts of 1938 were of exceptional severity and did a large amount of damage to the fruit crops in the plantations of the Research Station. Immediately after the first frost it was evident that much blossom had been injured and a survey of the damage in all parts of the plantations was made. The information collected gave an indication of the incidence of frost damage in different situations and on different varieties of fruit. The incidence of damage was also compared with that of the frost in May 1935 (1).

The following account records the available meteorological data and the extent of the injury sustained by various kinds and varieties of fruit in different parts of the plantations. Orchard heaters were not used in any part of the plantations and the blossom was therefore exposed to the full effect of the frost.

Altitude and Aspect.

The plantations cover an area of about 120 acres. They are situated in the bottom and on the lower slopes of a valley running from east to west. The northern portion of the plantations is separated from the main portion by a public road and a number of houses and farm buildings. To the north of the road the ground rises in a gradually increasing slope to a height of about 450 feet, the plantations extending up this slope to an altitude of about 250 feet.

The main portion of the plantations, in the bottom of the valley, occupies ground which is almost level from north to south, but slopes very gently towards the west : at the eastern end, however, the ground slopes more steeply east down to a brook at an altitude of 110 feet. The mean altitude of the level area is about 160 feet. A deep railway cutting runs from east to west through the centre of this portion.

Along the south side of the valley the ground rises, at first gently and then quite steeply, to a ridge about 250 feet in height. Apple trees are planted almost to the top of this north slope.

Shelter.

Almost the whole of the plantations are very exposed to winds from the east and the west. Buildings and a wood at the west end may afford a little shelter to a small area; apart from this, the only shelter is provided by three windbreaks, of poplar, beech and myrobolan plum respectively, which cross the more level part of the plantations from north to south.

Meteorological Data.

Data were obtained from the meteorological station situated in an open position near the centre of the plantations at an altitude of 160 feet, but no additional data are available for particular parts of the plantations. It is almost certain, however, that temperatures vary considerably in different parts of the plantations.

The following observations made at 9 a.m. record the minimum temperatures occurring during the previous night :—

				<i>Min. Screen.</i> (° F)	<i>Min. Grass.</i> (° F)
April 18	..	..	..	25	17
„ 19	..	..	..	28	18
„ 20	..	..	..	29	21
„ 29	..	..	..	29	19
„ 30	..	..	..	32	21
May 8	..	..	..	31	23

Less severe frosts were also recorded on other nights during the above period.

During the greater part of each night it was almost completely calm, though anemobiograph records show that there was a slight wind in the earlier part of some nights. The wind was N.E. on several of the nights of frost and S.W. on the others, the maximum velocity being 10 m.p.h. on two nights and 5 m.p.h. on others.

For purposes of comparison it may be noted that the minimum grass temperature in May 1935 was 21°, while during the blossoming period in 1938 the minimum was equal to this on two nights and lower on three other nights.

Blossom and Crop Data.

As soon as possible after the occurrence of the frosts a survey of the fruit trees and bushes in all parts of the plantations was made and records were taken of (1) the amount of blossom, (2) the state of development of the blossom, (3) the amount of damage to

the blossom. No actual counts were made, but the three quantities were estimated in the following ways :—

The amount of blossom was estimated according to a scale on which the figures 1 to 5 indicated the gradation from a very light bloom to a very heavy bloom.

The state of development of the blossom was indicated according to an estimate of the proportion of blossom which was open.

The amount of damage was indicated by an estimate of the percentage of blossoms in which the stigma or ovary was blackened and dead. This included unopened buds as well as open flowers.

Later in the year records were taken of the amount of crop in the various parts of the plantation and it was possible to check the estimated amount of frost damage with the crop obtained. On many plots detailed crop weight records were available : on others the records were less complete but sufficed to show the losses caused by the frost.

Effect of the Frosts.

Owing to the exceptionally warm weather which occurred during the early part of 1938 all fruit trees and bushes were very forward in growth, the dates of blossoming being about three weeks earlier than the average. On April 18th, when the first and most severe frost occurred, blossom was almost as far advanced as on the occasion of the frost on May 16th, 1935. As a general indication of the state of the blossom it may be stated that on plums all petals had fallen and many fruits had set, about threequarters of the petals of pears had fallen and about half the flowers of Bramley's Seedling were open.

After the first and most severe frost, on the night of April 17th-18th, it was seen that the blossom of almost every kind of fruit had been severely injured, and, while subsequent frosts did further damage, it seemed that the first two frosts produced the greater part of the damage.

(a) *Influence of Situation.*

On the higher parts of the plantations, *i.e.* at altitudes of more than about 200 feet, frost injury was relatively slight. For instance, above this height on Plots 21 and 22, on a south slope, the damage to blossom on standard Bramleys varied from 30% to zero, while the injury to other varieties of apples, including Cox in bush form, was also very slight. On the neighbouring Plot 23, in a similar situation, no damage to any variety of apple or gooseberry could

be detected in the higher part of the plot. Standard apples at a similar altitude on the other side of the valley, on a north slope, also sustained very little injury.

On the lower and comparatively level parts of the plantations damage was usually very severe and was definitely worst at the lowest points, from which there was no drainage for the cold air. One such point is near the brook at the east end of the plantations and here there was almost 100% injury to seedling apples, pears and plums. Another low area of maximum damage includes Plots 15A, 16 and 17A where James Grieve, Superb and Lanes, among apples, were injured to the extent of about 90%, while on Keepsake gooseberries and various black currants the damage was from 80% to 100%.

It was interesting to find that on the more level plots, excluding the lowest points, damage was most serious in the western half of the plantations, whereas in 1935 it was the eastern half which suffered more severely. A possible explanation of this is that there were slight drifts of the cold air in different directions on the two occasions. It seems probable that the accumulation of cold air in different parts of the comparatively level area is influenced by the strength and direction of the "hill-top" wind which usually blows, even during a frost.

In a grass orchard at one of the lowest points there was considerably more damage than in 1935. On a few young Bramley trees all the blossom was injured but the damage on cider varieties ranged from about 75% down to zero. The cider varieties, on the whole, appear to be relatively resistant to frost, and this, combined with the rather higher minimum temperature experienced in 1935, may account for the small amount of damage noted in this orchard in 1935.

Some plots slope gently from the 160 feet level up to about 190 feet and on these it was possible to trace the effect of this difference of altitude on the amount of damage. For instance, on Plots 14 and 15, where single varieties of apples are growing on various parts of the slope, the following amounts of injury were noted:—

				<i>Top of Plot.</i>	<i>Bottom of Plot.</i>
				%	%
Allington	..	..		50	90
Cox	..	..		75	90
Emmeth	..	..		25	75
Edward VII	..	..		0	10
Worcester	..	..		25	40

The crop weight records for the top and bottom halves of these plots do not reflect the amount of damage to the blossom. All the above varieties, except Cox, carried good or very heavy bloom, and there was enough uninjured blossom to provide a heavy crop on Emneth, Edward VII and Worcester on all parts of the plot. The Allington crop was light, being slightly better on the upper half of the plot, while Cox bore a very light crop.

On a neighbouring plot (Plot 11), in a similar situation to the last, the following damage was noted :—

				<i>Top of Plot.</i>	<i>Bottom of Plot.</i>
				%	%
Allington	..	..		25	50
Beauty of Bath	..	..		70	90
Bramley	..	..	..	80	100
Cox	..	..	..	5	80
Grenadier	..	..		75	95
Lane	..	..	..	80	95
Newton	..	..	..	30	100
Rival	..	..	..	30	95
Worcester	..	..		10	80

On this plot there was a large amount of blossom except in the case of Newton, on which it was rather light. Newton was the only variety which bore equally heavy crops on the upper and lower halves of the plot : in every other case the crop was heavier on the upper part where frost damage appeared to be less. With some varieties the differences were very great, *e.g.* the ratios of the crop weights on the upper and lower halves of the plot were : — Bramley 7 : 1, Cox 4 : 1, Allington 3 : 1, Worcester 2 : 1. While some of these differences may be due to other factors the amount of frost injury appears to have had a considerable influence on the size of the crop.

In the summer of 1938 Mr. C. E. Cornford, of East Malling, spent some time studying temperatures and katabatic winds in the plantations at Long Ashton. Through his courtesy we have been able to see the unpublished results of his observations, and it is interesting to see that, in general, the parts of the plantations which he indicates as being liable to experience the lowest temperatures on radiation nights are in fact the parts where the greatest frost damage was observed.

(b) *Varietal Susceptibility.*

Apples. Bramley appeared to be the variety most susceptible

to frost, as in many situations 100% of the blossom was injured. Allington, Cox and Lane also suffered severely, while Beauty of Bath, Grenadier, James Grieve and Monarch were only slightly less affected. Superb and Ellison's Orange appear to be among the more resistant varieties, while Emmeth and Worcester definitely suffered relatively little damage. Here it may be noted that Worcester was much more affected by the frost in 1935, but in that year the blossom was rather more advanced.

Edward VII. with not more than 10% injury, and Crawley Beauty with none, were the varieties most resistant to frost. Both these sorts blossom exceptionally late.

Cider varieties showed considerable differences in their susceptibility to frost injury, though, on the whole, they appeared to be more resistant than market sorts. It is also possible, however, that the smaller amount of damage to the cider trees is due to the fact that most of these are large standard trees whose branches form a "canopy," which may prevent the temperature falling to as low a level as it does in the open. The Bramley trees, to which 100% damage was done in this orchard, are young and stand in comparatively open spaces among the other trees. Damage to the extent of 75% was found on Bulmer's Norman, Dabinett and Kingston Black, while from 30% to 50% of blossom injury occurred on Cap of Liberty, Court Royal, Eggleton Styre, Foxwhelp, Frederick, Major and Sweet Woodbine. Varieties showing less than 10% damage included Cherry Pearmain, Chisel Jersey, Knotted Kernel, Medaille d'Or and Sweet Alford.

Plums. Most of the plums are on level ground near the lowest part of the plantations. They had carried a heavy bloom and most of the fruit was set or the petals had fallen at the time of the frost. There was a total loss on most varieties, the young fruitlets being blackened. The only sorts to show any resistance to frost were Czar, Pershore and Wye Cross (a new variety raised at Long Ashton), and even in those cases damage was about 95%, though the large quantity of bloom enabled the trees to produce a moderate crop from the surviving blossoms.

Black Currants. Damage varied according to situation but very little difference due to variety was observed. Possibly Seabrook and Boskoop suffered less injury than Baldwin, but there was almost a total loss of crop on all varieties in the worst situations. From 33% to 90% of the blossom was open at the time of the frost.

Red Currants. Several varieties showed an equally small amount of injury, which was confined to the berries near the tips of the trusses, but all were growing in an area of comparatively little damage. The fruits were swelling when the frost occurred.

Raspberries. Injury was very serious on most varieties, all of which were in the tight bud stage. Lloyd George was one of the most severely affected, 80% to 90% of the buds being killed, while Preussen showed only 20% to 30% of injury. Several Preussen seedlings also appeared to be fairly resistant. Several other seedling varieties which were rather badly damaged ultimately carried fairly good crops, apparently owing to the development of buds which would normally have remained dormant on the lower parts of the canes: this fruit ripened later than usual.

Strawberries. The first flowers on the trusses of Royal Sovereign were open and were all killed by the frost. Otherwise there was little damage and the total number of flowers injured seemed to be about 10%. As all the earliest blossom was killed, however, earliness and total crop yield were rather seriously affected. Paxton was uninjured and there was only slight damage on Oberschlesien and Tardive.

(c) *Other Factors Affecting Frost Injury.*

The degree of frost experienced in a particular situation may be affected by vegetation covering the soil. Cornford (2) has shown that lower temperatures occur over grass than over bare soil on radiation nights, and it is possible that frost injury to fruit trees may have been greater in grass orchards than in cultivated plantations at Long Ashton. Unfortunately very few comparable cases were available for observation, as most of the grass land is at a higher altitude.

On Plot 11 there are alternate strips of grass and arable ground, but no detailed observations of frost damage over the two treatments were made. The records for 1938 show that crops were heavier on the arable strips than on the grass for most varieties of apples, but this cannot be ascribed with any certainty to the effect of frost, as there is a tendency for this to occur each year owing to the nutritional effects of the treatments.

On Plot 16 the Lanes growing in grass appear to have sustained more damage than the same variety in cultivated ground on the adjacent Plot 15A. In this case, however, the ground, though almost level, may be a few feet lower on the plot where the greater

damage occurred. Lanes on Plot 7B (grass) also appeared to be more seriously injured than on Plot 7c (cultivated). In the two Plots 21 and 22, on the south slope, damage to Bramleys seems to have been slightly more in the grass (Plot 22) than in comparable positions in the cultivated ground (Plot 21).

Except in the case of exceptionally late-blooming varieties of apples, such as Crawley Beauty, Edward VII and Medaille d'Or, the stage of development of the blossom does not appear to have affected the amount of damage done, the varietal influence being greater. Thus a variety such as Lane, on which only a few flowers had opened, was more severely injured than Worcester, which was considerably more advanced. This point was well illustrated in the cider orchard, where the damage on different varieties with unopened flower buds ranged from 0 to 50%, while on varieties with half the flowers open the injury also showed the wide range of 10% to 75%. On any one variety buds and flowers in different stages of development were almost equally affected.

When observing the blossom the impression was gained that strong blossom suffered less than weak blossom, though no figures can be put forward in support of this idea. It is possible that the susceptibility to frost damage may be affected by the nutritional state of the plant.

Summary.

The series of frosts which occurred between April 17th and May 8th caused extensive injury to fruit blossom, the most serious damage being done on the first two nights. The effect of the frost was slight on the upper parts of north and south slopes and was definitely most severe at the lowest points in the plantations, where cold air collected. This result is similar to that found in 1935. On the relatively level ground which is slightly higher than the lowest points there was severe damage in parts, but the more seriously affected areas did not coincide with those of 1935.

There is some indication that apple trees in grass suffered more severely than those in cultivated ground, also that strong blossom was less affected than weak.

Apples, plums, black currants and gooseberries were seriously injured and strawberries were moderately affected. Distinct varietal differences in susceptibility to frost were found among apples, Worcester and Emneth being relatively resistant and Bramley very susceptible. Very late blossoming apples, such as

Crawley Beauty and Edward VII. were almost immune. Among plums, Czar, Pershore and Wye Cross were found to be the most resistant varieties, while in raspberries, Lloyd George was badly affected, but Preussen was fairly resistant.

Except in the case of the varieties which bloom exceptionally late, the stage of development of the blossom did not appear to affect the amount of injury sustained by apples.

REFERENCES.

- (1) SPINKS, G. T., and SWARBRICK, T. The Frost of May 1935. *Ann. Rept. Long Ashton Res. Sta.*, p. 31, 1935.
- (2) CORNFORD, C. E. Some Meteorological Factors Affecting the Distribution of Frost Damage to Fruit Trees. I. *Journ. Pomology and Hort. Sci.* Vol. XVI, No. 4, p. 291, 1939.

A NOTE ON THE RELATION OF ABSORPTION TO VIGOUR IN APPLE STOCKS.

By W. E. BERRY.

The classification of rootstocks is based on the degree to which they influence the scions grafted on them. A vigorous stock is understood as one that induces vigorous growth in the scion as opposed to the stunting effect of a dwarfing stock.

Vigour appears to be a quality inherent in the stock itself, and stock influence as such undoubtedly plays a large part in determining the behaviour of a grafted tree. The nature of the graft union and the character of the scion, however, may be factors of no less importance in certain combinations.

It is not proposed to attempt here a definition of vigour, nor to assess the merits of the various criteria which have been used as a measure of this property. Shoot growth, tree height and spread, and trunk girth have been frequently adopted for this purpose, but at best they provide but an arbitrary standard of comparison.

Increase in dry weight is the most reliable measure of growth, and there can be no question that the vigour of a tree is expressed by its ability to increase its own dry weight. On this basis the most reliable comparison of the vigour of different stocks is obtained by comparing their percentage increases in dry weight accumulated in a given time. No doubt this criterion would have been widely adopted were it not for the obvious disadvantage that dry weight can only be obtained by killing the tree. In these circumstances it seems there would be considerable value in determining which of the more usual measurements, such as girth, shoot growth, etc., is most closely correlated with increase in dry weight.

The underlying causes of vigour and dwarfing present a problem which has long exercised the minds of research workers. The fact that stock characters can be passed on from a stock to its scion points to a physiological or biochemical origin, but so far little success has been achieved from attempts to seek an explanation along these lines.

The following is a brief account of a preliminary enquiry into the

extent to which the vigour of a rootstock may be related to its capacity for absorbing mineral solutes. The fact that an intermediate stem piece may influence vigour must not be lost sight of, but it seems that such pieces may affect the root as much as the scion.

The investigation was conducted on a very small number of stocks, and the results can only be taken as indicating a possible future line of attack.

Experimental.

Four stocks each of M IX, M II and M XIII from the stool beds were planted in sand in 12-inch pots after removing all roots and obtaining the fresh weight of each stock. The dry weights were estimated by multiplying the fresh weights by a factor obtained from similar material.

The sand was kept moist with rain water until the buds were about to break, when a complete nutrient solution was applied every other day. On the remaining days the cultures received 500 cc. of .001 M potassium bromide solution. The bromide ion, which is non-toxic and readily absorbed, was used as an indicator of the amount of absorption. Later in the season the strength of the solution was increased to .005 M and applied every day.

At the beginning of August, when the trees had made considerable growth, they were harvested and each was divided into young and old leaves, bark and wood of upper, middle and lower stem and shoots, and roots. The fresh and dry weights of these fractions were determined and the dry material analysed for bromide.

The complete data for these fractions are not given here since they throw little light on the problem of stock differences. The figures for the whole trees, however, are of some interest.

Table I contains the dry weight data for the complete trees of each stock. The initial order of size of the stocks on the basis of dry weight was XIII > IX > II and this was also the final order, the biggest stocks accumulating most dry weight. When calculated as percentage increases, however, the order becomes XIII > II > IX, which is the accepted order of vigour of these stocks. Applying Student's test to the means in pairs and using Fisher's *t* table, the differences appear highly significant in all cases.

Table II gives the total amounts of bromide absorbed for each

tree, from which it appears that the order of stocks in this respect is the same as that for vigour. The data, however, are not conclusive, for whilst the difference between the means for stocks XIII and IX is significant, that between stocks XIII and II just fails to be significant at the 5% point and that between II and IX is definitely not significant. The small number of trees used no doubt accounts largely for this lack of precision. The suggestion remains, nevertheless, that some relation may exist between absorption and vigour, and it is particularly worthy of note that absorption is related to increase in dry weight rather than to the absolute size of the tree.

TABLE I.

	<i>Initial Dry Weight (gms.)</i>			<i>Final Dry Weight (gms.)</i>			<i>% Increase in Dry Weight.</i>		
	XIII	II	XI	XIII	II	IX	XIII	II	IX
	31.75	15.25	29.25	79.36	32.87	49.45	149.9	115.5	69.07
	28.75	17.75	27.50	74.78	41.67	56.38	160.1	134.8	105.1
	28.50	16.25	24.75	71.19	37.67	45.47	149.8	131.8	83.7
	33.25	15.50	23.50	83.34	34.86	50.08	150.7	124.8	113.1
Mean	30.56	16.19	26.25	77.17	36.77	50.35	152.4	127.1	91.7

S.E. XIII, II = 7.029.

S.E. XIII, IX = 14.66.

S.E. II, IX = 15.46.

TABLE II.

	<i>Total mgm. equivs. bromide absorbed.</i>			
	XIII	II	IX	
	1.364	1.014	0.840	S.E. XIII, II = 0.252 S.E. XIII, IX = 0.207 S.E. II, IX = 0.227
	1.485	0.985	0.942	
	1.067	1.330	0.775	
	1.784	0.670	1.174	
Total	5.700	3.999	3.731	
Mean	1.425	0.999	0.933	

COMBINED WASHES.

PROGRESS REPORT.—V.

By H. G. H. KEARNS and H. MARTIN.

During 1938 much of the field experimental work on combined washes was spoiled by the disastrous frosts of the second and third weeks of April following an exceptionally early growth of all fruit crops. There is accordingly little to report on the post-bud-burst combined washes which have formed the subject of previous progress reports (1, 2, 3, 4), and the present report is confined to trials of sprays normally applied before bud burst.

It is the established practice to apply petroleum oil washes at and just after bud burst for the control of capsid bugs in the egg stage, a practice which necessitates the prior application, during dormancy, of a tar oil wash for the control of aphid and Apple Sucker. This separate spray application could be avoided by the incorporation, in the petroleum oil spray, of a material toxic to aphid and Apple Sucker, a question discussed in a previous Report (5). The possible materials there mentioned included 3 : 5 dinitro-*ortho*-cresol and certain organic thiocyanates. Compound products containing the cresol are now commercially available, but the thiocyanate, dodecyl rhodanate, the subject of the earlier work, has not yet been placed on the market. A related thiocyanate, β -butoxy- β^1 -thiocyanodiethyl ether, more conveniently called butyl carbitol thiocyanate, has however appeared as an active component of a proprietary ovicidal wash.

The point for immediate investigation was whether combined washes of either of these products and petroleum oil, when applied at the bud burst stage usual for straight petroleum oil washes, would cause serious damage to the buds. It is evident from a consideration of the hatching date of aphid, Sucker and Winter Moth eggs that the thiocyanate or cresol would be applied too late to kill the eggs of these pests, but information was required of the insecticidal effect of the washes and of their phytocidal action on apples, currants and gooseberries after bud burst.

Further, both combinations were applied to plums just before the hatching date of Plum Aphid in order to ascertain the control

obtained and the effects of the washes on well advanced buds. Experiments were also carried out on the control of Plum Aphis by means of Grade A tar oil, because it had been suggested that low concentrations of tar oil washes in certain highly infested localities failed to provide a control.

EXPERIMENTAL.

Materials.

The petroleum oil conformed to the specification Grade E (6). It was prepared as a stock emulsion by milling with the 20 per cent. solution of sulphite lye (60°TW.) and contained 67 per cent. oil.

The butyl carbitol thiocyanate used contained 75 per cent. by volume of the thiocyanate and 25 per cent. kerosene. It was added to the petroleum oil before the latter was milled.

The dinitro-cresol washes were prepared from proprietary products, one compounded from the cresol itself, the second from the sodium salts. The former wash contained, in addition to 0.1 per cent. dinitro-*ortho*-cresol, 5.0 per cent petroleum oil (Grade E) and a protein emulsifier. The second contained, in addition to 0.1 per cent. sodium dinitro-cresylate, an undetermined but small amount of spreader stated by the manufacturers to be of the alkylated naphthalene sulphonate type.

The tar oil emulsion consisted of Grade "A" anthracene oil milled with 15 per cent. solution of sulphite lye (60° TW.), and contained 60 per cent. of oil.

Experiments on Apples.

A block of 945 five-year-old apple trees, of the varieties Worcester Pearmain, Laxton Superb, Cox Orange Pippin, was divided into seven equal sized blocks of 135 trees. Six blocks were sprayed with the experimental washes, and one left unsprayed as a control. The washes were as follows :—

<i>Wash.</i>				<i>Concentration Applied.</i>	
1.	Butyl carbitol thiocyanate	..	..	..	0.3 per cent.
	Petroleum oil	..	..	..	3.0 "
2.	Butyl carbitol thiocyanate	..	..	..	0.3 "
	Petroleum oil	..	..	..	5.0 "
3.	Dinitro- <i>ortho</i> -cresol	..	..	..	0.1 "
	Petroleum oil	..	..	..	5.0 "
4.	Sodium salts of dinitro- <i>ortho</i> -cresol	..	..	..	0.1 "
5.	Nicotine (97%)	..	..	..	0.05 "
	Petroleum oil	..	..	..	3.0 "
6.	Petroleum oil	..	..	..	3.0 "

The washes were applied in liberal quantities on the 25th March, 1938, when the blossom buds of the Worcester Pearmain and Cox Orangé Pippin trees were at the very early green flower stage, and the Laxton Superb at the early to mid-green flower stages. The aphides, principally *A. pomi*, had just hatched from eggs and were present on the outside of the buds. Winter Moth eggs were hatching. Red Spider eggs did not hatch until the end of April.

Records of phytocidal injuries were made and it was apparent that only the washes containing dinitro-cresol caused any injury. The extent of the injury depended on the stage of development of the blossom buds and not on the variety. It was negligible up to the very early green flower stage, after which the damage became progressively more serious to mid-green flower stage. From the mid-green flower stage, buds were in many instances completely killed.

The final records of the infestations of the pests were made on the 18th May, on which date the aphid and Winter Moth attacks had reached their maxima, whilst the Red Spiders were still congregated on the smaller leaves and thus aided assessment of the infestation. The results obtained are recorded as percentages of trees infested, in the following table:—

PERCENTAGES OF TREES INFESTED, 18/5/38.

Treatments.	<i>A. pomi</i> .		<i>C. brumata</i> .		<i>O. ulmi</i> .	
	Slight.	Medium.	Slight.	Medium.	Slight.	Medium.
1. Thiocyanate 0.3 Petroleum oil 3.0	50	34	86	9	35	0
2. Thiocyanate 0.3 Petroleum oil 5.0	27	0	82	0	32	0
3. D.N.C. .. 0.1 Petroleum oil 5.0	50	0	73	0	77	0
4. Na Salts of D.N.C. ..	27	14	100	0	5	77
5. Nicotine .. 0.05 Petroleum oil 5.0	65	0	85	0	40	0
6. Petroleum oil 3.0	59	5	82	0	50	9
7. Unsprayed ..	36	41	82	4	4	95

The results show that none of the washes provided a satisfactory control of aphides that had just hatched from eggs nor of Winter Moth that was hatching from eggs at the time of application of

the wash. All of the washes containing the oil at 3.0 per cent. or 5 per cent. provided an appreciable control of the winter eggs of Red Spider. The sodium salts of D.N.C. failed to control Spider, but the oil washes containing the thiocyanate provided a slightly higher control than the other oil-containing washes, a similar small difference being noted in the laboratory trials.

Currants.

The washes applied to the apples were also applied on the same date to Westwick Choice, Seabrook, Baldwin and Boskoop black currants which were just past the tight cluster flower bud stage, and to Raby Castle and Laxton No. 1 red currants, the buds of which were opening.

All the varieties of the black currants were severely damaged by the dinitro-cresol washes. Foliage scorch was evident and ultimately nearly a complete loss of crop occurred, with subsequent retarded growth of the foliage. The other washes did not cause any extensive foliage damage, but some "running off" of the flower racemes was noted, more particularly when the oil content was 5.0 per cent. The addition of the thiocyanate to the oil did not appear to increase its phytocidal properties. This oil damage was expected, as previous experiments had shown that an oil of this refinement (unsulphonated residue = 77.5 per cent. by vol.) could not be used with safety on black currants later than the very early "tight-grape" stage.

The red currants were undamaged by any of the washes.

Gooseberries.

The gooseberry varieties Whinham's Industry and Leveiler were also sprayed with the same washes as the apples on 24th and 25th March. The foliage was well advanced in growth and the flower racemes exposed. The dinitro-cresol washes caused very severe damage to the foliage and resulted in a complete loss of crops. The other washes caused negligible amounts of injury.

Plums.

- (a) **The Control of Plum Aphis (*Anuraphis padi*) by dinitro-*ortho*-cresol and butyl carbitol thiocyanate washes.**

Dinitro-*ortho*-cresol and butyl carbitol thiocyanate were applied

in combination with petroleum oil at the following concentrations :—

{ Dinitro-ortho-cresol	..	..	0.1 per cent.
{ Grade E petroleum oil	..	..	5.0 „
{ Butyl carbitol thiocyanate	..	..	0.3 „
{ Grade E petroleum oil	..	..	3.0 „

A block of 40, 16 ft. high x 9 ft. wide, Pershore Yellow Egg plums were divided into two equal-sized blocks. The washes were applied at the rate of 3 gallons per tree under difficult windy conditions on February 9th when the buds were swelling and the bud scales still held together. In each block 4 trees were left unsprayed. The aphid eggs commenced to hatch on the 18th February.

In early April, the blossom was examined and no sign of damage could be found on the sprayed trees. Aphid was present on the unsprayed control trees. On May 28th, a final examination was made. The frosts had caused a total loss of fruit. The unsprayed trees were very severely damaged by aphid. Both washes had provided a nearly complete control of aphid, just a few odd branches, which had obviously been missed in the spraying, showing signs of infestation. The infestation by Red Spider on the control trees was insufficient to allow of making significant records.

(b) *Control of Anuraphis padi by means of Grade A Tar Oil Washes.*

A block of 288 medium-sized plum trees, of the varieties Rivers' Prolific, Czar and Pershore Yellow Egg, were divided into six blocks of 48 trees. On three of these blocks, picked at random, a Grade A tar oil emulsion was applied at a concentration of 3.0 per cent. Grade A tar oil. On the remaining three blocks the wash was applied at 5.0 per cent. of the oil. Three control, unsprayed trees were left at random in each block. The wash was applied on the 8th and 9th February, just before bud burst under windy conditions, and on one block of trees sprayed with the 3.0 per cent. oil rain fell before the wash had dried on the bark.

The trees were examined in late April when no sign of blossom bud damage was noted. At the end of May a final examination was made, and the unsprayed trees were so severely infested by aphid that nearly complete defoliation had occurred. The trees sprayed with the 3.0 and 5.0 per cent. tar oil were free from infestation. A small amount of aphid was noted on the block of trees on which the wash had insufficient time to dry before rain fell.

The trial showed that it was unnecessary to apply a tar oil emulsion at a concentration of more than 3.0 per cent. Grade A tar oil to ensure a control of aphids. The result suggests that the inferior control of aphids occasionally obtained with this concentration is due to inadequate spray tackle or to indifferent spraying.

SUMMARY.

The phytocidal properties of dinitro-*ortho*-cresol and butyl carbitol thiocyanate, each used in conjunction with petroleum oil, were examined.

It was shown that the dinitro-*ortho*-cresol washes cannot be applied to apples later than the very early green flower stage without risk of serious injury. Black currants and gooseberries with the flower buds exposed suffered complete loss of crop. Red currants proved more tolerant.

The washes failed to control aphids that had just hatched from eggs. Washes containing 3.0 per cent. or more of petroleum oil provided an appreciable control of Fruit Tree Red Spider eggs.

When applied to plums before egg hatch, the washes provided a high control of Plum Aphid (*A. padi*) and could be applied with safety just before bud burst.

Grade "A" tar oil emulsions applied at 3.0 per cent. concentration of the oil provided a complete control of Plum Aphid, and could be applied just before bud burst without causing flower bud injury.

REFERENCES

- (1) KEARNS, H. G. H., MARSH, R. W. and MARTIN, H. "Combined Washes—Progress Report." *Annual Report, Long Ashton Research Station*, pp. 66–85, 1932.
- (2) KEARNS, H. G. H., MARSH, R. W. and MARTIN, H. "Combined Washes—Progress Report II." *Ibid.*, pp. 37–48, 1935.
- (3) KEARNS, H. G. H., MARSH, R. W. and MARTIN, H. "Combined Washes—Progress Report III." *Ibid.*, pp. 99–117, 1936.
- (4) KEARNS, H. G. H., MARSH, R. W. and MARTIN, H. "Combined Washes—Progress Report IV." *Ibid.*, pp. 65–77, 1937.
- (5) KEARNS, H. G. H. and MARTIN, H. "Investigation on Egg-killing Washes." *Ibid.*, pp. 49–57, 1935.
- (6) MARTIN, H. "The Standardization of Tar and Petroleum Oils and Preparations as Insecticides." *Ann. Appl. Biol.*, XXII, 334–414, 1935.

EXPERIMENTS ON THE CONTROL OF PESTS OF APPLE NURSERY STOCK BY MEANS OF DIPPING.

WOOLLY APHID AND RED SPIDER.

PROGRESS REPORT No I.

By H. G. H. KEARNS and E. UMPLEBY.

The importance of keeping apple nursery stock free from pests is well recognised. It is equally important to maintain this freedom from injury after planting the trees out in permanent quarters, particularly during the first year. Dessert and culinary varieties in commercial plantations receive routine spraying with winter and spring washes, which provides a satisfactory control of pests, but in the case of cider and culinary varieties in farm orchards the trees are not given close attention after planting out except in exceptional circumstances.

In the West Country, Woolly Aphid (*Eriosoma lanigerum* Hausm.) more especially on cider varieties grown on crab stocks, is frequently present on the stems and roots, and during the first 5-7 years of the life of the tree may cause considerable injury to the growing head. Of late years, Fruit Tree Red Spider (*Oligonychus ulmi*) has become increasingly prevalent on nursery trees and at times the infestations are sufficiently severe to warrant special control measures. It is therefore evident that it is desirable to treat the trees before planting out with insecticides to control these two pests, and at the same time other species of aphides and of Apple Sucker.

Experiments (1) had shown that the dipping of nursery trees in a tar oil emulsion (9.0 per cent. Grade A tar oil) provided a reasonable control of Woolly Aphid. Subsequent experiments emphasized that careful preparation of the trees by washing the roots prior to dipping was of more importance than using a high concentration of tar oil (Fig. 1). As a result of the latter work practical methods of treatment were formulated (2).

The complete removal of the earth from the roots of the trees

as recommended was contrary to accepted nursery practice, and it was suggested that this practice, in conjunction with the complete immersion of the tree in a tar oil wash, would frequently result in the death of the tree. The preliminary experiments did not show any ill effects, but it was clear that the treatment should be extended to a large number of trees for confirmation. A large scale field trial carried out in the winter of 1937-38 showed that the treatment provided a satisfactory control of Woolly Aphid and that the loss of trees was negligible. As the wash used contained both tar and petroleum oils, observations were also made on the control of other pests in addition to Woolly Aphid and Red Spider.

Experimental.

Material.

1,421 trees, consisting of the varieties Bramley's Seedling, Knotted Kernel, Yarlington Mill, Bulmer's Norman, Sweet Alford, Dabinett, Medaille d'Or and Ellis Bitter, on seedling root stocks and propagated in the Research Station nurseries, were lifted and dipped between November 10-26th, 1937. All the trees were later transported by road to a site in Devon, and planted in hillside pastures sloping down to the river Dart. Three hundred were planted into their permanent quarters within a few days of dipping, whilst the remainder were first heeled in at Long Ashton and subsequently lifted in convenient numbers and planted between early December and mid-February.

The majority of the trees prior to treatment were severely infested with the eggs of Red Spider and, on nearly every tree, colonies of Woolly Aphid were evident on the stems and roots. It was impossible, however, to ascertain the exact percentage of the trees infested with the latter pest, because of the difficulty of noting the aphides hidden between the callus of wounds. Occasional eggs of other aphides were noted.

The Wash.

A tar oil-petroleum emulsion (3) was prepared at Long Ashton consisting of 30 per cent. by volume of Grade A tar oil (4), 30 per cent. Grade E petroleum oil (4), and 40 per cent. of 15 per cent. sulphite lye solution. The concentrate was diluted to prepare a wash containing 3.0 per cent. tar oil and 3.0 per cent. petroleum oil. These latter concentrations were selected because the tar oil was sufficient to kill Woolly Aphides and the eggs of other species

of aphides and Apple Sucker, whilst the petroleum oil, according to laboratory toxicity tests, was sufficient to ensure a high control of Red Spider and in addition to aid in the penetration of the wool of the Woolly Aphides. The combined concentration of the two oils was sufficient to provide a control of the eggs of Winter Moth (*Cheimatobia brumata*).

Under commercial conditions trees are lifted over a long period and therefore it was desirable to avoid the expense of repeatedly filling a dipping tank with fresh wash. To simulate these conditions the original wash was kept in the tank for over four months and during this period 2,000 trees were dipped in it. At intervals the wash was examined and the emulsion was found to have remained stable. The only precaution found necessary was to agitate before use since the emulsion creamed. The tank was protected against dilution by rain water, but not against frost.

Method of Treatment.

The trees were dipped in the wash contained in a galvanized tank 12 ft. $\times$ 3 ft. $\times$ 3 ft. Each foot depth of the tank required 225 gallons of wash. A depth of two feet of wash was necessary for the satisfactory immersion of the trees. The most efficient method of treatment was as follows:—

The trees were lifted and placed in water contained in a trough or in butts to soften the earth on the roots, which were next thoroughly hosed with water and allowed to drain. Each tree was then inspected and all obvious colonies of Woolly Aphid brushed with the wash. After this treatment batches of trees in convenient numbers were completely immersed in the tank for a few moments. The trees were then lifted clear of the wash by means of rubber-covered steel hooks on handles and then re-immersed for about two minutes, this operation greatly facilitating the penetration of the wash into wound calluses by breaking air films. A period of 30 minutes immersion did not cause any injury. Finally the trees were stacked vertically against strained wire or other support and allowed to dry off, and when dry they were either heeled in or planted into permanent quarters.

Results and Discussion.

The trees were well planted in holes, dug or blown out. In normal seasons the sloping pastures were well supplied with moisture but they partly dried out in the exceptionally dry spring

of 1938 and thus the newly planted trees did not have the best soil conditions for re-establishing their root systems after the drastic treatment. All the trees were critically examined on May 23rd and 24th by three observers for condition and presence of pests, the dates being selected because they coincided with a period when the Woolly Aphid was producing conspicuous colonies on the stems of infested trees. The colonies arose in many instances from a solitary aphid in a scar wound on the stem or on a rootlet that had escaped the toxic action of the dipping wash. Moreover, this period was the most favourable for the determination of the hatch of spiders from winter eggs. The majority of the eggs had hatched and the spiders had congregated on the small leaves on the basal portions of the shoots of tree heads and on the small leaves of blossom buds.

Observations were made on the prevalence of other species of aphides and of Apple Sucker and winter moths. The results were as follows :—

(a) *Mortality of Trees.*

99.8 per cent. of the trees were alive and in healthy condition.

(b) *Infestation of Various Pests.*

<i>Pest.</i>				<i>Percentage Trees Infested.</i>
Woolly Aphid	..	..	..	10.0
Red Spider	..	..	..	74.7*
Winter Moths	..	..	..	80.0†
Apple Sucker	..	..	..	0.0
Other Aphides	..	..	..	0.0
Other pests	..	..	..	0.0

* 44.9 per cent. of the trees very slightly infested.

† Mainly March Moth ; infestation occurred after dipping and planting.

The slightest evidence of the presence of Woolly Aphid was recorded as an infestation since one aphid on a tree was regarded as sufficient ultimately to cause a severe infestation. The figures for the Red Spider control do not reflect the high control actually obtained by the petroleum oil of the wash. Most of the trees prior to dipping had thousands of winter eggs on the bark, and trees recorded as very slightly infested had less than 50 spiders on the foliage. Trees marked as infested had more than 100 spiders present. The numbers of living spiders expressed as percentages

of total eggs showed a control of the latter of the order of 94 per cent., which is the figure obtained from laboratory toxicity trials. The relatively low numbers of spiders on the trees at this period of the year, under favourable climatic conditions, might be sufficient to build up a large population and cause appreciable injury to the tree and thus a complete or nearly complete control is necessary to ensure a satisfactory result from a winter ovicide on this type of tree.

March Moths and Winter Moths caused appreciable to severe damage on a number of trees and the infestation must have occurred after planting and not from an infestation at Long Ashton, as untreated control trees left at Long Ashton were entirely free from attack of Winter Moth. March Moth did not lay its eggs until well after the date of removal from Long Ashton. An examination of the hedgerows and trees in and near the hillside pastures showed clearly that the infestation must have come from these, either by moths finding their way to the trees or by the first instar larvae being carried by wind to the trees.

The trial may be regarded as incomplete in that untreated trees were not planted on the same hillside pastures, although some were left at Long Ashton for observation. The conditions at the two centres were sufficiently similar to make comparable comparisons concerning the control of the various pests.

It was evident that the removal of all earth from the tree roots and complete immersion of the tree in a combined wash of tar and petroleum oils did not interfere with the subsequent growth of the tree after planting out. The control of Woolly Aphid, though high, was not complete. Observations showed that re-infestation resulted mainly from aphides hidden in the cavities formed between the curved lips of calluses growing over wounds resulting from the removal of side shoots (Fig. 2). These hidden aphides were protected by their wool and an air layer which prevented intimate contact with the wash.

The control of Red Spider, according to laboratory evaluation toxicity tests, would not be increased appreciably by a greater concentration of the petroleum oil, although an increase to 5.0 per cent. in the wash would ensure a control of capsid bugs, a fact that would alone justify an increase in concentration. This higher concentration of oils does not result in any damage to the trees.

Summary.

A trial to test the efficiency of dipping apple nursery stocks in a



FIG. 1.—An apple rootstock infested with Woolly Aphides which are hidden by adhering earth. The latter must be removed to ensure adequate wetting of the aphides by winter washes.



FIG. 2.—Open wounds on a stem become infested by Woolly Aphides and between the incurved tips of the callus some of the aphides may remain protected from washes.

winter wash, containing tar and petroleum oils as a means of controlling Woolly Aphides and the eggs of Red Spider, showed :—

1. The removal of soil as completely as possible from the roots of lifted nursery apple trees, followed by complete immersion of the trees in a winter wash, consisting of 3.0 per cent. Grade A tar oil and 3.0 per cent. Grade A petroleum oil, did not interfere with the subsequent growth of the trees.

2. The control of Woolly Aphid was high but incomplete, because of the difficulty of obtaining complete contact between the wash and aphides hidden between callus growths over wounds.

3. The control of the winter eggs of Red Spider by the petroleum oil although relatively high was insufficient to ensure freedom from the pest when the tree was severely infested with eggs.

4. A sulphite lye emulsion of the tar and petroleum oils remained stable in the dipping tank over the whole winter.

Acknowledgment.

Thanks are due to Mr. A. Wilkins, Research Assistant, for his able help.

REFERENCES.

- (1) KEARNS, H. G. H. and UMPLEBY, E. "The Control of Woolly Aphid *Eriosoma lanigerum* Hausm on Nursery Stock." *Ann. Rept. Agr. and Hort. Res. Stat., Long Ashton*, pp. 67-75, 1935.
- (2) KEARNS, H. G. H. and UMPLEBY, E. "Woolly Aphid (*Eriosoma lanigerum* Hausm). A serious pest of nursery stock and established cider orchards." *Herefordshire County Council Agric. Quart. Journ.*, 4, 4, pp. 153-157, 1936.
- (3) KEARNS, H. G. H. and MARTIN, H. "The Use of Sulphite Lye as an Emulsifier." *Ann. Rept. Agric. and Hort. Res. Stat., Long Ashton*, pp. 118-123, 1936.
- (4) MARTIN, H. "The Standardisation of Petroleum and Tar Oil and Preparations as Insecticides." *Ann. Appl. Biol.*, XXII, 333-414, 1935.

APPLE CANKER INVESTIGATIONS.*

By R. W. MARSH and R. G. MUNSON.

The Supply of Spores of the Canker Fungus.

The most serious form of canker in apple trees is caused by a fungus, *Nectria galligena*, which produces two kinds of spores, conidia and ascospores. The conidial fructifications appear on cankered bark as dirty-white strips consisting of masses of unenclosed spores. These spores separate from one another when wetted and are readily washed off and scattered by drops of rain. Conidia are produced abundantly in March and April and again in September and October, but less freely in the summer months. The second type of spore—the ascospore—is formed in groups of eight within closed bodies called perithecia. These perithecia are dark red, pear-shaped structures about one sixty-fourth of an inch across and they occur clustered on the older cankers. Perithecia are produced in maximum numbers from October to December and are least frequent during the summer.

When a ripe perithecium is wetted it shoots out ascospores, in successive groups of eight, through an apical pore, to a distance of approximately one inch. Ascospores thus ejected may be carried away and disseminated by wind-blown rain. Observations made from October 1936 to November 1937 at Long Ashton showed that ascospores were being discharged during wet periods throughout the year. The maximum discharge took place in February, the numbers then falling off steadily to a minimum in September and rising again during the autumn and winter. During dry periods no ascospores were liberated, but apart from this, there was no season in which spore discharge was at a standstill. Cold weather provided a check to spore expulsion, and at temperatures below 40°F. very few spores were set free. At 50°F. spore discharge was vigorous.

Ascospores germinate over a range of temperature from 35° to 87°F. Germination takes 36 hours at 35°F., 24 hours at 60°F. and

*This article is a summarized version of the following two papers appearing in the *Annals of Applied Biology*, Vol. XXVI:—(1) The discharge and germination of ascospores of *Nectria galligena*, by R. G. Munson; (2) The incidence and control of canker on apple shoots, by R. W. Marsh.

3 hours at 68° to 78°F. Even at 35°F. the final percentage germination is not adversely affected. Spores kept dry for 5 to 6 days, however, lose the power of germination.

It is apparent that frost and dry weather will inhibit the discharge and germination of canker spores, but that they may be disseminated during wet weather *at all times of the year*. Spore discharge is at its lowest in the summer; in the autumn and spring the supply of ascospores is supplemented by that of conidia, and in the winter months ascospore production is at its maximum. This maintenance of infective material throughout the year is a feature in the life history of *Nectria galligena* which is not found in that of any other fungus attacking the apple, and it provides one of the reasons for the difficulty experienced in controlling the canker disease.

The Infection of Leaf Scars.

The researches of Wiltshire (Long Ashton Ann. Rept., 1920, p. 82), showed that canker frequently infected shoots through the scars left on leaf-fall. Experiments were carried out in 1937 to determine: (1) whether shoots of Cox's Orange Pippin showed any seasonal variation in susceptibility to this type of infection; (2) whether control of leaf scar infection could be obtained by spraying. Preliminary experiments showed that spores of the canker fungus were remarkably resistant to sulphur sprays, so the fungicide selected was Bordeaux mixture modified with casein and petroleum oil to improve its wetting and sticking properties. The spray used was made up as follows:—

Copper sulphate	8 lb.
Hydrated lime	16 lb.
Casein	4 lb.
Petroleum oil (grade G)	1 gall.
Water	100 gall.

This spray was applied to one group of 20 young trees of Cox on January 29, to another series of 20 on April 5, and to a third on October 4. After being sprayed, the trees were inoculated, without wounding, by placing small fragments of *Nectria galligena* cultures on the leaf scars. On each occasion that 20 sprayed trees were inoculated, parallel inoculations were made on groups of 20 unsprayed trees.

The results of the experiments may be summarized thus :—

Date of Treatment.	Number of infections per 20 inoculations.	
	On unsprayed shoots.	On sprayed shoots.
29th January ..	0	0
5th April	16	6
4th October	6	1

These results indicate that leaf scar infections take place most readily in the spring, less rapidly in October, and not at all in January. The spray treatment applied is seen to give a fair measure of control.

Infections of Pruning Cuts.

As it is a matter of common observation that cankers may originate at pruning cuts, investigations were undertaken to determine the susceptibility to infection of pruning cuts at various dates and at different times after pruning. Pruning wounds were made on a uniform batch of 240 young trees of Cox's Orange Pippin, of which 100 were cut in October, 70 in December and 70 in March. In each series, certain wounds were left unprotected ; the remainder were treated, directly after pruning, with one of the wound paints listed below. One third of the October-pruned shoots (protected and unprotected) were inoculated within 24 hours of pruning, one third were inoculated in December, and the remainder in March. Similarly, half the December-pruned shoots were inoculated shortly after pruning and the remainder in March, while the March-pruned shoots were inoculated half in March and half in May. The complete scheme of the experiment is given in the table below.

Inoculation was carried out by placing a fragment of *Nectria galligena* culture on the cut surface and binding round with crepe rubber, which was removed after a fortnight. The wound protectant materials tested at various times between 1935 and 1938 included white lead paint, soft grafting wax, mercuric cyanide in glycerine, cuprous oxide in cottonseed oil, oil-Bordeaux (as used in the leaf scar infection experiments) a bituminous emulsion, and a copper-lime-linseed oil mixture. A summary of the results for the 1937-38 trial is given in the following table.

PRUNING CUT INFECTION EXPERIMENT. NUMBERS OF SUCCESSFUL
CANKER INFECTIONS IN EACH SERIES OF SIX INOCULATIONS.

Date of Pruning ..	Oct. 12			Dec. 14		Mar. 14	
Date of Inoculation	Oct. 13	Dec. 15	Mar. 15	Dec. 15	Mar. 15	Mar. 15	May 20
<i>Wound Treatment.</i>							
Unprotected ..	6	0	0	6	1	6	4
Unprotected ..	6	0	0	5	1	—	—
Cuprous oxide-oil ..	5	1	0	5	1	4	2
Bordeaux-oil ..	6	1	1	5	2	6	5
Bituminous emulsion	6	1	0	6	2	6	4
Copper-lime-linseed oil	no tests					0	0

It will be noted that freshly-made cuts are infected with equal readiness in October, December or March. Provided that the canker fungus can reach a new pruning wound it can infect it at any time in the dormant season or the spring. Wounds made in October or December, however, apparently acquire a natural immunity on ageing and cannot be readily infected when two months or more have elapsed since the time of pruning. This phenomenon is not shown by the wounds made in March, which are still susceptible to infection in May.

Concerning the trial of wound protectants it must be emphasized that the test employed was a very stringent one, involving the maintenance of a relatively heavy dose of infective material in close contact with the cut surface under moist conditions. In these circumstances the only protectant which combined safety and ease of application with prevention of canker infection was the copper-lime-linseed oil mixture. In a small number of tests (12) this paint gave complete protection. The formula is as follows:—

Monohydrated copper sulphate ..	5 lb.
Hydrated lime	10 lb.
Boiled linseed oil	7 pt.

Practical Considerations.

The records of spore discharge show that the supply of infective material in the autumn, winter and spring is checked only during periods of frost and dry weather. Thus there are more chances of

temporary cessation of spore discharge during the coldest months of the year, so that pruning in mid-winter rather than in autumn or spring increases the possibilities of escaping infection. If, however, wet and mild conditions occur, newly made wounds are liable to infection at all seasons. The practice of protecting pruning cuts will obviously have only a limited application, but for nursery stock and young trees of canker-susceptible varieties the use of the copper-lime-linseed oil paint merits further trial.

On the subject of leaf-scar infections, it would appear that the present standard spraying programme for apples—tar oil in winter, petroleum oil in March, and lime sulphur plus insecticides in spring and summer—has no direct fungicidal action on the canker fungus. The inclusion of a Bordeaux spray in the spring is suggested where canker is a serious problem. This Bordeaux application might replace the first pre-blossom lime sulphur spray or, preferably, be added to the March petroleum wash. This would give a routine treatment against canker without lengthening the spraying programme. It was pointed out in a previous article (Bath and West Journal, 6th Series, Vol. XI, p. 42), that canker is much dependent on conditions and that it may often be reduced by cultural methods, in particular by grassing down. For nursery stock and young trees, however, such a check to growth is inadmissible, and it is towards a solution of the canker problem in young trees that the experiments described in this paper have been specially directed.

Summary.

1. The ascospores of *Nectria galligena* are set free by violent ejection from the perithecium.

2. Spore discharge ceases during dry periods and is much reduced below 40°F., but during wet periods spores are set free at all times of the year. The maximum discharge occurs in February, the minimum in September. Conidia are disseminated principally in spring and autumn.

3. Ascospores can germinate in water at all temperatures from 35° to 87°F., but lose the ability to germinate after five days desiccation.

4. Canker infections through leaf scars may be initiated in October and April, but not in mid-winter. A fairly good control of leaf scar infections was obtained by preventive spraying with a Bordeaux-casein-oil mixture.

5. Freshly-made pruning cuts are susceptible to canker infection throughout the autumn, winter and spring. Cuts made during autumn and winter acquire a natural immunity to infection within two months.

6. Several wound-sealing materials applied to pruning cuts failed to give protection from canker when the treated surfaces were inoculated with *Nectria galligena*. The most promising wound protectant tested was a mixture of monohydrated copper sulphate, hydrated lime and linseed oil.

A NOTE ON THE PREVALENCE OF FUNGAL SPOTS AND ROTS OF APPLES IN COLD STORE AT LONG ASHTON.

By E. H. WILKINSON.

Each year samples of apples, collected from representative orchards situated in the main fruit-growing areas of England and consisting of the most popular culinary and dessert varieties, are placed for observation in cold storage at Long Ashton. Most of the samples are picked during September and stored, at the latest, three days after picking. Great care is taken that only apparently clean and sound fruits are stored. The samples are picked from trees specially selected to investigate the effects of various factors on keeping quality, such as special cultural, manurial and other orchard practices, or rootstocks, age of trees, etc. From time to time during the storage period each sample is carefully examined in order to estimate the keeping qualities of the fruits.

An investigation into the incidence of fungal rots and spots and identification of the respective causal organisms was started during the storage season of 1937. The rots appearing on the apples during that period were identified and listed under the various samples to determine the degree of correlation obtaining between the number, type and severity of rots and the special features of the trees, including districts from which they were collected.

In this note it is not intended to give the results in detail, as it is proposed to do this in a later paper, but to record only certain points which appear to be of interest and practical importance.

The apples from the 1937 crop were examined in detail on three occasions during the storage period, in December 1937, February 1938 and April 1938. The store was completely cleared after the April sampling.

Similar samples of apples picked from the same localities were again stored in September 1938 and the counts are being repeated in order to compare them with those for 1937.

Fungi responsible for rots.

Laboratory examination and isolation showed that the following fungi were responsible for the rotting and spotting of the apples. They are placed in the order of severity of attack as shown by the counts :—

1. *Gloeosporium album* Osterw.
2. *Botrytis cinerea* Pers.
3. *Penicillium expansum* Thom.
4. *Sclerotinia (Monilia) fructigena* Aderh. and Ruhl.
5. *Cylindrocarpon Mali* (Allesch.) Wollenw.
6. *Alternaria* sp.
7. *Rhizopus stolonifera* (Ehrenb.) Lind. (= *R. nigricans* Ehrenb.).
8. *Gloeosporium fructigenum* Berk.
9. *Cephalothecium roseum* Corda.
10. *Diaporthe* spp.
11. Miscellaneous fungi :—
 - Sphaeropsis malorum* Peck.
 - Pleospora pomorum* Horne.
 - Fusarium* sp.

Details relating to these fungi are given below.

1. *Gloeosporium album* Osterw.

On the results of the counts this fungus proved to be the one causing most damage to stored apples, as already indicated by Ogilvie (2). After a normal growing season it makes its appearance towards the end of November and increases in severity with time.

The fungus enters the apple typically through the lenticels, forming circular, sunken, brown lesions. Each lesion has a lenticel at its focus. In its initial stages the rotted area is approximately 3 mm. in diameter but expands radially to a diameter of 40 mm. to 50 mm. Certain apple varieties are apparently more susceptible to attack although all sorts held in store have been found, at one time or another, to be affected. The susceptibility of some varieties, e.g. Cox's Orange Pippin, Allington Pippin, Worcester Pearmain, and Laxton's Superb, may have some relationship with their lenticular structure. It is quite common to find apples of the varieties Cox's Orange Pippin, Allington or Worcester with five, ten or even fifteen separate infections, but these are usually small in diameter. In contrast, Bramley's Seedling and Grenadier

usually have a smaller number of infections to each apple, but the rots can attain diameters up to 50 mm.

G. album has also been isolated from eye rots originating from an open calyx, from stalk-end russetting of Cox's Orange Pippin and Laxton's Superb, and from a secondary invasion around the peripheries of scab lesions. These modes of attack, however, are comparatively uncommon.

All the samples stored in 1937 showed attack by this fungus. The lowest count recorded was 2%. The highest count was obtained from Worcester grown at Long Ashton on Plot 7B. This sample consisted of 3,576 apples divided into 12 lots, each lot consisting of fruits gathered from a known rootstock. The severity of the attack due to *G. album* can be judged from a count of 47% infection due to this fungus out of a total count of rots amounting to 54%.

The effect of nitrogenous manure is shown in the counts derived from Worcester grown near Ross-on-Wye. Those under "low nitrogen" treatment showed a 10% infection of *G. album*, while those receiving "high nitrogen" showed a 31% infection.

Cox's Orange Pippin grown at Chelmsford, Essex, had a 41% infection by *G. album*, the majority of the lesions having started in the russeted areas around the stalk ends of the apples.

The varieties Bramley, Grenadier and Derby, showed low percentage rotting and appeared to be more resistant to the disease.

2. *Botrytis cinerea* Pers.

In certain samples rotting due to this fungus was very severe. It is very difficult, however, to estimate the actual number of initial infections in a sample as the fungus spreads by contact so rapidly from one apple to another when the fruits are not wrapped. For example, one tray of Laxton's Superb yielded a solid mass of infected apples, 37 in number, all attacked by *B. cinerea*. It is possible that this damage was the result of one initial infection.

Examination of large numbers of apples has shown that those suffering from stalk-end russet, e.g. Cox's Orange Pippin and Laxton's Superb, wrenched or broken stalks, cracked skin and stalk or insect punctures are very susceptible to attack. Once the fungus has gained an entry it rapidly rots the whole apple.

Apples grown on special manurial plots at the Somerset Farm Institute, Cannington, suffered most from this fungus. Three

samples of Laxton's Superb showed 21%, 22% and 27% infection, while Worcester showed 23%. Other counts for comparison were, Long Ashton, Worcester 6%; Swanley (Kent) Worcester 3%; Cox's Orange Pippin from Essex 20%; Long Ashton Newton Wonder 3%; Grenadier from Cheshire 3%; and East Malling Bramley 1%.

3. *Penicillium expansum* Thom.

Rots due to this fungus usually appeared to play a minor part in the incidence of rotting in the cold store. In the Cannington Worcesters, however, it was responsible for 25% of the rots. This severe rotting arose as a secondary invasion around the periphery of scab lesions which were fairly plentiful in this sample.

P. expansum usually attacks apples through open wounds, rapidly reducing them to a total rot. At the same time the rotting is accompanied by the copious production of green sporing masses (coremia) over the whole surface of the apple.

Some of the samples showed no rots due to *P. expansum*, while others only showed percentages of infection ranging between 1% and 3%.

4. *Sclerotinia (Monilia) fructigena* Aderh. and Ruhl.

As an orchard parasite this fungus is very well known, but it would seem from the counts made that it is not such a serious disease in storage as it is sometimes considered to be. It is essentially an early appearing rot and only attacks fruit suffering from some form of mechanical injury. The infected apples rot rapidly and within a week or two after storage the attacked fruits can be distinguished by their deep brown or black colour and buff-coloured spore masses on the surface of the skin. The rotting is capable of being spread by the spores to neighbouring fruits, but if the infected apples are removed immediately no further trouble from this rot may be anticipated.

East Malling Bramley showed the highest infection due to *S. fructigena* (3%). Other samples had 1% or less and some were quite free.

5. *Cylindrocarpon Mali* (Allesch.) Wollenw.

This fungus is the conidial stage of *Nectria galligena* Bres., the common canker organism, and is found not uncommonly producing

eye rots of apples while still on the trees. In storage it occasionally causes a circular lenticular rot with an external appearance not unlike that caused by *Gloeosporium album* Osterw. Most samples yielded no rots due to *C. Mali*, but a few (it is interesting to note only in Worcester samples) showed cases of lenticular rot, *e.g.* from Kent 1%, from Chelmsford 0.5% and from Long Ashton 0.5%.

Worcesters grown in mid-Somerset were affected to the extent of 7%. All the infected apples suffered from a very severe calyx-end rot which in all cases involved half the apples and sometimes more. This severity of attack may bear a direct relationship to the occurrence of a severe "canker" infection on the trees from which the apples were picked.

6. *Alternaria* sp.

Most samples provided a few apples rotted by this fungus. The attack was, for practical purposes, negligible and no sample showed a preponderance of this rot. In no sample was an infection of 1% exceeded. This was in contrast to the prevalence of this rot in 1933, as recorded by Ogilvie (2).

7. *Rhizopus stolonifera* (Ehreb.) Lind. (— *R. nigricans* Ehrenb.).

The incidence of this type of rot is comparable with that caused by an *Alternaria* sp. Very few rots were found primarily infected by *R. stolonifera*. It occurred, however, quite frequently, infecting apples which had burst or cracked skins following flesh breakdown. One sample of Cannington Worcesters, which had received a "Complete" manurial treatment, showed 2.8% infection. The attack had started in this case through scab lesions.

8. *Gloeosporium fructigenum* Berk.

This is the cause of comparatively rare disease in stored apples. Superficially the rot is identical with that produced by *G. album* and can only be distinguished from the latter by microscopic examination of the spores which are straight and not curved as in *G. album*. The fungus also shows marked cultural differences from the latter. It is a lenticel invading fungus. In these present experiments it was found only in a few cases, in samples of Worcester and Laxton Superb from Cannington, and in Bramley from East Malling.

9. *Cephalothecium roseum* Corda.

This fungus is the cause of the disease commonly called "Pink Rot." It was found only in a few cases causing a slight marginal rot around scab lesions in Worcester from Cannington. On five occasions, in this sample, it was isolated in a pure state from very pale brown lenticular rots. This is quite a rare occurrence. It is suggested that the conidia of this fungus became dispersed over the surface of the fruits, from spore masses surrounding nearby scab lesions, and set up a slight infection through the weakened lenticels.

10. *Diaporthe* spp.

Rots due to species of *Diaporthe* are found in storage only late in the season. The instances recorded in the 1937 counts were found only during the February sampling date. Two distinct species so far have been isolated in culture, but identification is not quite completed. It appears that the two species may be *D. perniciosa* Marshall and *D. eres* Nit. The first has been isolated from time to time by previous workers from apple rots occurring late in the storage period. Kidd and Beaumont (1), as a result of their work, state that when apples are stored for any considerable period the importance of this fungus is second only to that of *Penicillium expansum*, but, being essentially a late storage rot, it is relatively unimportant during the short period apples are normally kept. *D. eres*, so far as the writer is aware, has not been previously described as causing a rot of apples. The rots due to these two species cannot be distinguished and their differentiation is only possible after culturing.

The suspected *D. perniciosa* was isolated from Worcester grown on the Long Ashton Grass and Arable plot (0.6%, representing four infected apples), and from Worcester from Cannington (0.5%, representing eight infected apples).

The suspected isolations of *D. eres* were obtained from one rot of the variety Bismarck and from two rots of East Malling Bramley.

11. *Miscellaneous fungi*.

Sphaeropsis malorum Peck., *Pleospora pomorum* Horne and *Fusarium* sp. were isolated on one or two occasions only.

S. malorum was isolated from a Long Ashton Worcester showing a severe eye rot. The infection was characteristic in that the skin was marked with alternating light brown and dark brown rings. Observation seemed to indicate that these were related to alternating periods of day and night.

Pleospora pomorum was isolated on two occasions from lenticel spots of the variety Charles Ross.

A *Fusarium* sp. (identification not yet complete) was isolated on three occasions from Bramley and from a Cannington Worcester. In each case it caused a rot starting at the base of a damaged stalk. The attack of this fungus is peculiar in that it penetrates the core and then rots the tissue outwards. Sometimes a small, light brown area around the stalk is the only indication of its presence, but when the apple is cut open most of the flesh is completely rotted. The rot is light brown in colour and very spongy.

Conclusion.

The above notes record the fungi responsible for the rotting of apples held in cold store at Long Ashton from 1937 crops. Instances of the incidence of attack of each specific fungus are quoted.

Further work is being carried on by the writer into the relationship of twig infections or cankers of trees in the orchard with the type of rotting found in apples taken from these trees, in continuance of the previous work of Ogilvie (2).

Summary.

1. Details are given regarding the species of fungi causing rots of apple fruits from crops in 1937, obtained from trees grown under various treatments, etc., in different fruit growing districts of the country and cold stored at Long Ashton.

2. The prevalence of the various types of rots is indicated.

3. The counts showed the most prevalent rot to be of the lenticular type caused by the fungus *Gloeosporium album* Osterw. *Botrytis cinerea* Pers. also caused a considerable amount of rotting of fruits suffering from stalk-end russetting, especially in the varieties Cox's Orange Pippin and Laxton's Superb. The other species listed were less severe in their attack, some causing slight amounts of lenticular rots, and others agining entrance by way of mechanical injuries.

REFERENCES.

- (1) KIDD, M. N., and BEAUMONT, A. "Apple Rot Fungi in Storage." *Trans. Brit. Mycol. Soc.*, 10, pp. 98-118, 1924.
- (2) OGILVIE, L. "The Fungus Flora of Apple Twigs and Branches and its Relation to Apple Fruit Spots." *Journ. Pom. and Hort. Sci.*, 13, 2, pp. 140-147, 1935.

PROGRESS REPORT ON VEGETABLE DISEASES.—X.

By L. OGILVIE, H. E. CROXALL and C. J. HICKMAN.

The following report is a brief summary of the work on Vegetable Diseases in the Bristol Province carried out during the season 1937-38, and is a continuation of those published previously.

ASPARAGUS DISEASES.

Asparagus Rust.

Occurrence of the Disease. Asparagus Rust (*Puccinia Asparagi*) is being made the subject of a special survey and investigation. The disease was not found in 1938 till August 20th, although the field at Badsey, near Evesham, where it occurred in 1937, was examined frequently. By that date two patches of "bower" in the previously infected 2-year-old bed were already dead and the remainder had turned yellow. Three neighbouring beds were also infected. At North Littleton a 2-year-old bed and neighbouring older beds were diseased. There was apparently a heavy infection in this latter district in 1934. Other districts were unaffected at this date.

There was little development by September 3rd but by September 27th much spread had occurred in both districts, and by October 17th nearly all the plantings in the Littleton and Badsey Fields areas were infected to some extent, while slight infection was observed in the Bretforton district.

Special Investigations. No early appearance of rust took place in a field of asparagus where calcium cyanamide was applied to the soil at 5 cwt. per acre after badly infected bower had been cut. The disease became apparent, however, in a neighbouring 2-year-old bed.

In October and November 1938 the rust was found to be commonly parasitised by the fungus *Darluca filum*. *Botrytis cinerea* was also frequent on rust lesions in moist weather and appeared to check its

development to some extent. This fungus has been described from Germany affecting asparagus in an identical fashion (2).

An investigation has also been undertaken to determine how long the uredospores and teleutospores remain viable. Uredospores remain viable for two weeks on cut bower, which should therefore always be burned without delay. A small percentage of the teleutospores on old pieces of stem are capable of germination from December onwards. The time of their germination appears to be connected with the time at which they were formed and the weather conditions during the winter. Pycnidia and oecidia have been induced in March by suspending pieces of stem bearing teleutospores over forced asparagus shoots.

Control. Field surveys have again emphasised the importance of young beds in carrying over the disease from season to season, a fact which has been stressed by Gassner and Hassebrauk (1) in North Germany, and which has already been pointed out by ourselves. The bower of these beds is often not cut till their second year, hence debris bearing teleutospores is apt to remain on the ground throughout the winter. Again, the young shoots or "buds" from such beds are too small to be cut, and the oecidial stage on them is liable to be undisturbed and to give rise to a uredospore epidemic. The spraying of such young beds might be practicable.

Most growers remove the old bower and burn it, but three or four inches of stem are commonly left in the ground. In infected fields these stem bases are normally covered with teleutosori (Fig. 1). These "sticks," as they are called by growers, are usually knocked out during cultivation in early spring and are collected and burned, but it is probable that many remain in the ground and give rise to new oecidial infections. The importance of cutting bower low down near the soil and of destroying old sticks has been pointed out to growers.

Violet Root Rot of Asparagus.

Two more cases of Violet Root Rot have been discovered. The disease often suddenly attacks several plants in an otherwise healthy field far removed from outside infection, which possibly points to carrying of the fungus by birds. Again, in two cases, new areas about 6 yards in diameter were revealed by yellowing of the bower in late summer, and it is evident that considerable spread may take place during one season. A special leaflet on the disease



FIG. 1.

Teleutosori of Asparagus Rust, on old Asparagus "Sticks." Badsey, Evesham, October 1938.
The "Stick" second from the left bears a pycnidial fungus.

has been issued. The most careful growers now dig up and burn the plants on the diseased areas and isolate them by means of trenches and sheets of corrugated iron. Of the soil treatments applied in 1932, 1 in 1,600 mercuric chloride applied at the edge of the affected areas, after complete removal of the diseased plants, seems to have been the most effective (3).

CELERY DISEASES.

Celery Blight.

Celery "seed" was collected in the autumn of 1937 from plants severely infected with *Septoria Apii*. About 8,000 seeds were dusted with methyl mercury nitrate, methyl mercury phosphate, four proprietary organic mercuries and cuprous oxide respectively, and then sown in boxes of sterilised soil, about 2,000 seeds per box. Four boxes were also sown with untreated seeds. The boxes were kept very moist and were covered with glass for a month after sowing. Two months after sowing there was a considerable amount of disease in some of the boxes, as shown by Table I.

TABLE I.
EFFECT OF SEED DRESSINGS ON AMOUNT OF *SEPTORIA APII*
ON SEEDLINGS.

<i>Seed Dressing.</i>	<i>No. of Patches of Septoria in four Boxes.</i>			
Control	17,	2,	0,	0
Methyl mercury nitrate	1,	0,	0,	0
Methyl mercury phosphate	0,	0,	0,	0
Cuprous oxide	2,	0,	1,	1
Proprietary dressing containing tolyl mercury acetate ..	1,	1,	1,	1
Proprietary dressing containing phenyl mercury acetate ..	0,	0,	0,	0
Proprietary dressing containing ethyl mercury chloride ..	0,	0,	0,	0
Proprietary dressing containing ethanol mercury carbide	0,	1,	0,	0

It will be seen that some of the dressings hold promise of being effective, but the amount of disease present did not allow of any conclusive result. Celery seeds dressed with the proprietary dust containing phenyl mercury acetate were reported by local growers to give disease-free crops in previous years.

DWARF BEAN DISEASES.

Field Trials.

Stocks of the following resistant varieties of dwarf beans have been worked up.

Resistant to Fusarium Foot Rot. Long Ashton Resistant Strains were placed on trial with a grower at Bretforton, near Evesham, and proved highly successful where ordinary varieties succumbed to foot rot.

Stocks of the following received from New South Wales were also worked up; Keeney's Refugee Foot Rot Resistant. Keystone Valley Stringless.

Resistant to Mosaic Disease. Wisconsin Refugee and Mosaic Resistant Refugee.

Resistant to Halo Blight. Burnley Selection of Canadian Wonder received from New South Wales.

RUNNER BEAN DISEASES.

Wilt.

The *Fusarium* causing the wilt of runner beans previously referred to in these reports (3, 4, 5) has been identified by D. L. G. Davies as *F. vasinfectum* Atk. var. *lutulatum* (Sherb). Wr. and further information on its biology, to be published elsewhere, has been obtained by him.

LEEK DISEASES.

Foot Rot.

The *Fusarium* causing foot rot of leeks in the Evesham district, previously referred to in these reports (6, 7) has been identified by D. L. G. Davies as *F. culmorum* (W.G. Sm.) Sacc. A new and severe outbreak of the disease occurred in the Fladbury district in July, 1938.

Rust.

Rust, caused by *Puccinia Porri*, was prevalent throughout the Evesham area in October and November 1938. badly affected plants being much stunted. As in previous years, however, the plants outgrew the disease and by the spring the top leaves were perfectly healthy.

LETTUCE DISEASES.

Classification of Lettuces.

Further progress was made with the classification of lettuces. Five groups were differentiated on the basis of flower and leaf characters.

Lettuce Mosaic.

The observations on lettuce mosaic have now been completed and have been incorporated in a joint paper with Dr. G. C. Ainsworth.

ONION DISEASES.

White Rot.

White Rot, caused by *Sclerotium cepivorum*, was again prevalent and is being made the subject of a special study. It was found that early autumn sowings tended to be more severely affected than late sowings, no doubt owing to the higher temperatures prevalent during the earlier period. A pot trial carried out by D. L. G. Davies indicated that differences of pH had little bearing on infection.

PEA DISEASES.

Pea "Sickness."

From the results of previous work (8) it was suggested that certain varieties of peas bred in the U.S.A. for resistance to Fusarium Wilt might also be resistant to pea "sickness," associated with the eelworm *Heterodera Schachtii*. Some dozen varieties of such peas were obtained from American seedsmen and sown in a very highly infested piece of ground at Bretforton, near Evesham. Certain of these gave highly satisfactory growth and yield, especially the variety "Gilbo" which grew vigorously on infested soil and produced healthy foliage and pods acceptable to growers.

Bacterial Disease of Peas.

The bacterial disease of peas referred to in the 1928 Report (9), and probably caused by *Bacterium Pisi* (Sackett) E. F. S., was common in trial plots at Long Ashton, and also at Evesham in June.

Pea Seed Treatments.

Field trials of cuprous oxide dressings on pea and other seeds have been continued and will be reported on more fully elsewhere. In commercial fields in Somerset considerable increases in emergence have been obtained. Similar results followed the use of certain organic mercury dressings and in this case there was apparently some stimulation to growth.

At Long Ashton rows of cuprous oxide treated and untreated peas were sown, each row containing the same number of seeds. The varieties were Earliest of All and Foremost. Two sowings of each were made, one in November and one in February. A count was made of the number of seedlings emerging in each row. The stand was up to 100% better in the treated rows. The weight of peas picked from each of the rows was also recorded. The yield from the treated rows was 30-40% greater than from the untreated rows.

A trial carried out during the summer suggested that certain varieties of peas are more susceptible to pre-emergence damping-off than others.

OTHER INVESTIGATIONS.

Control of Damping-off.

Various chemicals were tested against damping-off, as described later in this Report (p. 98).

Seed Treatments.

Increases in germination followed cuprous oxide treatment of the following seeds: peas, sugar beet, tomato, cucumber, sweet pea. Zinc oxide gave increased germination in the case of cabbage, turnip, radish and lettuce.

Boron Deficiency Trial.

Some twenty different varieties of vegetables were sown or planted in a boron-deficient sugar-beet field, near Milverton, Somerset, half the plot being treated with borax. Unfortunately no clear symptoms of boron deficiency were visible on these or on the beets in the surrounding field, probably owing to the favourable growing conditions in the latter part of the season.

REFERENCES.

- (1) GASSNER, G. and HASSEBRAUK, K. On Asparagus Rust and its Control. *Deutsche. Landwirt. Presse*, 6, pp. 215, 216, 1934.
- (2) HASSEBRAUK, K. *Botrytis cinerea* Pers. als Spargelschädling. *Nachricht. für d. Deutsch. Pflanz.*, 18, I, p. 2, 1938.
- (3) OGILVIE, L. and MULLIGAN, B. O. *Ann. Rept. Agr. and Hort Res. Stn., Long Ashton, Bristol*, pp. 100, 101, 1933.
- (4) Do. do. p. 107, 1932.
- (5) Do. do. p. 104, 1933.
- (6) Do. do. p. 108, 1932.
- (7) Do. do. p. 109, 1933.
- (8) Do. do. p. 112, 1932.
- (9) Do. do. p. 191, 1928.

THE CONTROL OF DAMPING-OFF FUNGI BY MEANS OF CHEMICALS APPLIED TO THE SOIL, WITH SPECIAL REFERENCE TO WEAK FORMALDEHYDE SOLUTIONS.

By L. OGILVIE, C. J. HICKMAN and H. E. CROXALL.

In the course of work now in progress on the effectiveness of certain seed dressings against pre-emergence damping-off (20), known numbers of pea seeds, dressed and undressed, were sown in boxes of soil in the greenhouse. Counts of the numbers of peas which germinated gave a measure of the effectiveness of the dressings. It was realized that the same method could be employed to give a measure of the effectiveness of soil fungicides against damping-off fungi in the soil, since the fungi, mainly *Pythium* sp., responsible for pre-emergence damping-off of pea seeds, are also the cause of post-emergence damping-off of many kinds of seedlings.

In view of the large number of publications on the damping-off problem which have appeared recently the present paper gives a review of the chief fungicides which have been found to be of value. The second half of the paper gives an account of experiments, on the lines described above, in which the value of most of these chemicals was assessed.

Previous Experiments.

Excellent accounts of previous work on the damping-off problem have been given by Alexander, Young and Kiger (1), Bewley (3), Cunningham (5), Horsfall (15), Martin (17), and Newhall and Chupp (19).

The usefulness of chemicals designed for the control of damping-off depends on several factors.

Toxicity to Fungi. As will be seen, the fungicides vary in their toxicity to specific fungi, thus copper compounds are valuable in the control of damping-off due to Phycomycetous fungi, such as *Pythium* and *Phytophthora*, but are of little value against *Rhizoc-*

tonia. Formaldehyde, again, is relatively ineffective against *Botrytis*. The ideal soil fungicide should be effective against a wide range of pathogenic soil fungi.

Toxicity to Plants. The ideal soil fungicide should be relatively harmless to plants. Weak solutions of potassium permanganate have this virtue, but are comparatively feeble fungicides. Cheshunt Compound was specially designed by Bewley (2) to possess the triple advantages of fungicidal value, harmlessness to plants and usefulness as a fertiliser.

Some soil fungicides are so phytocidal that they have to be applied to the soil weeks or months before sowing or planting. In recent years the tendency has been to rely more on fungicides which can be applied to the soil after sowing the seeds or actually to the soil amongst the plants themselves.

An interesting point is the specificity of injury by some of the fungicides. Thus cuprous oxide is harmful to the seeds of Brassicæ (13) and probably to seeds of certain varieties of peas, copper fungicides may be especially toxic to tomato and other plants, corrosive sublimate is harmful to tomatoes and cauliflowers but not to cabbages, while acetic acid and pyroligneous acid can be safely applied to seed-beds of conifers after the seed has been sown but are decidedly dangerous in the case of other plants.

Penetration into the Soil. Most chemicals applied to the soil in aqueous solution are either chemically fixed or adsorbed by the surface layers so that they penetrate only to the depth of a few inches at most, indeed this is the chief difficulty to be overcome in finding an effective soil fungicide. The most effective fungicide would be one which penetrates rapidly through the soil to the same extent as the water which holds it in solution. Fungicides which are volatile to some extent are likely to have considerable penetrability, hence the value of such a substance as formaldehyde.*

The ideal soil fungicide therefore should be highly toxic to many species of pathogenic fungi and should not be toxic to plants. It should penetrate easily through the soil and it would be preferable for it to remain effective for some considerable time so that the soil is not readily re-invaded and the plants growing in it remain protected. Finally the cost of the material should not be excessive.

*cf. Hunt, N. R., O'Donnell, F. G., and Marshall, R. P., Steam and Chemical Soil Disinfection, with Special Reference to Potato Wart. *J. Agri. Res.*, 31, pp. 301-363, 1925.

Chemicals Employed Against Damping-off.

1. *Mercuric Chloride* (corrosive sublimate, HgCl_2).

This chemical has been used effectively by Clayton (4) at a dilution of 1 in 1,000 and by Preston (23) at a dilution of 1 in 2,000 for the control of Club Root of Brassicae. It has also been used successfully by Dahl (6) as a dry powder, mixed with sand, at the rate of 3 oz. per 1,000 sq. ft. against snow mould of grasses, caused by *Fusarium nivale*, and is now commonly recommended for this purpose.

Gloyer and Glasgow (10), while working on the control of cabbage maggot by corrosive sublimate, found it was also effective against damping-off of cabbage, caused by *Corticium Solani*, and Horsfall, (15) states that even at the present time this is probably the best method for controlling damping-off and wirestem of cabbage caused by this fungus. Cabbage growers in the United States use it at the rate of 1 in 1,600, dribbling it along the row of seedlings from a tank mounted on wheels. It should be noted that cauliflower and Brussels sprouts are more susceptible to injury, and in their case 1 in 2,500 is suggested (19). Again, Wiant (26) found that corrosive sublimate at about 1 in 2,000 gave good control of damping-off in conifer seedlings, while Thomas (25) found that mercuric chloride (1 in 2,000) controlled damping-off of tomatoes caused by *Phytophthora* and *Rhizoctonia* respectively.

The substance has, however, certain disadvantages. It is very poisonous. It is readily adsorbed by the soil particles and hence penetrates very feebly. It is also liable to cause injury to certain plants. Thus Thomas (25) found that tomato plants were susceptible to injury by corrosive sublimate while cabbages were less susceptible and, as stated above, cauliflowers have also been found to be injured by the chemical.

2. *Calomel* (mercurous chloride, Hg_2Cl_2).

Calomel was used by Monteith and Harmon (18) for the control of brown patch of turf, caused by *Rhizoctonia* spp. It was found to be the most effective of fourteen mercury preparations tested, from the point of view of control, toxicity and cost. It was also found by Dahl (6) to be effective in the control of snow mould of grasses. The material was applied in a dry or liquid form, at concentrations comparable with those at which corrosive sublimate was used.

Wiant (26) found that a single application of dry calomel at the time of seeding, $3\frac{1}{2}$ to $5\frac{1}{2}$ ozs. per 1,000 sq. ft. of bed, controlled damping-off, mainly caused by *Rhizoctonia*, of Norway spruce, red pine and white pine.

Calomel has the same disadvantages as corrosive sublimate and is, in addition, sparingly soluble in water, so that it is usually applied in a dry form.

3. *Organic Mercury Compounds.*

The organic mercury compounds, of which there are many on the market at the present time, have been found to be as effective as corrosive sublimate and calomel in cases where these give good control. They have given good control of *Rhizoctonia* diseases of turf (19), of crucifers (25) and of conifer seedlings (26).

They have also been found to control damping-off of tomato seedlings caused by *Phytophthora*, if applied as a precautionary measure when the tomatoes were planted, but were of little value after damping-off had appeared.

A Ceresan-kaolin dust was found by Alexander, Young and Kiger (1) to give considerable promise when mixed with the soil before sowing tomatoes, but the difference between the amount necessary to bring about control and the amount causing injury was very slight.

Organic mercurials, especially the more recent forms, have been found to give excellent protection of certain seeds from seed-rotting fungi, and are especially valuable in the case of peas where the damping-off fungus *Pythium ultimum* is mainly concerned.

The organic mercurials have been found to cause injury in certain circumstances, as in the case of the inorganic mercurials, and should therefore be tried out on a small scale before any wholesale application is made. Since they are mainly sold as proprietary articles, one has also to bear in mind the possibility of alterations in their composition from time to time.

4. *Copper Sulphate* ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$).

Copper sulphate, though highly toxic to the phycomycetous damping-off fungi, is not a satisfactory soil fungicide on account of its high toxicity to certain plants and its ready adsorption by the soil particles so that it remains in the surface layers. It appears to be only slightly toxic to *Rhizoctonia* spp.

It has the advantages, however, of being readily soluble and of remaining in the soil for some time after treatment so that the latter is protected against recontamination.

In some soils and on certain crops copper sulphate, at the rate of 1 lb. in 25 gallons of water, applied to the soil at the rate of 2 pints per sq. ft., appears to have given good results (19), but its behaviour is very uncertain; for example, it injures tomato seedlings badly (1). Horsfall (15) in one field test found that 0.5 and 1% solutions applied to peas after sowing gave increased germination.

5. *Copper Carbonate* (CuCO_3 , Cu(OH)_2).

The term copper carbonate is somewhat loosely applied to basic copper carbonate, and sometimes mixtures of this with calcium carbonate or calcium hydroxide or these added to aqueous solutions of copper sulphate go under the same name (5). Basic copper carbonate is practically insoluble in water and has been largely used as a cereal seed dressing against smuts.

Kadow and Anderson (16) found that at the rate of 1 oz. to 3 gallons of water it gave fairly good results in the control of damping-off of tomato, cabbage and other vegetables.

Thomas (25) found that copper carbonate, when applied to the soil previous to planting or afterwards when damping-off had already commenced, produced no injury to tomato seedlings. It controlled damping-off caused by *Phytophthora* in the former case, but not in the latter.

Newhall, Chupp and Guterman (19) recommend the use of copper carbonate at the rate of 1 lb. to 25 gallons of water, applied to the soil at the rate of 2 pints per sq. ft. The mixture is not harmful to foliage owing to its sparing solubility, but where an excess is used it may retard growth. It may also be used as a dust, raked into the surface soil at the rate of 1 lb. to each 100 sq. ft.

6. *Cheshunt Compound*.

Bewley (2) attempted to neutralise the toxicity of copper sulphate to plants and its feeble penetration into soils by mixing it in a finely powdered form with ammonium carbonate at the rate of 2:11 by weight. 1 oz. of the material is added to 2 gallons of water. It is commonly used in England for the control of post-emergence damping-off of seedlings and can be applied to most plants without injury. The ammonia liberated acts as a fertiliser. It is stated by Cunningham (5), however, to be of little value as a soil disinfectant.

7. *Bordeaux Mixture.*

At the usual rates of 4-4 50 or 5-5 50 Bordeaux Mixture has been found in some cases to be highly effective against damping-off affecting seedlings (19), but like other copper compounds it has poor penetrability and is not toxic to all damping-off fungi. Of six treatments tried against post-emergence damping-off, Kadow and Anderson (16) found it the most effective. It completely arrested damping-off in four days in all their tests. Stunting of growth tended to result, however, in the case of crucifers and cucurbits. According to Horsfall (15) the lime in Bordeaux Mixture may stunt certain seedlings badly, hence cuprous oxide is preferred by him. Recently copper oxychloride has also been used as a seedling spray.

8. *Cuprous Oxide* (Cu_2O).

The use of cuprous oxide as a seed protectant was first recommended by Pirone et al. (22), and has recently been largely developed by Horsfall (13). The latter has since recommended its use as a foliage spray and in the prevention and control of damping-off by watering or spraying the seedlings, or even dipping the seedlings in a copper oxide suspension at transplanting time.

Red cuprous oxide is comparatively harmless to most plants and the toxic ion is apparently liberated slowly so that its toxic or protective effect persists in the soil for some time. It is, however, injurious to certain types of seeds. It definitely injures Brassicæ, while Compositæ and Malvaceæ should be treated with caution.

9. *Aluminium Sulphate* ($\text{Al}_2(\text{SO}_4)_3$.)

This chemical has been applied to nursery beds of forest trees both in the dry and liquid form and has given good results (26). The rate is 16 to 20 lbs. per 1,000 sq. ft. of bed surface, dissolved in sufficient water to wet the beds thoroughly, and applied immediately after sowing. Horsfall (15) found it had distinct value on tomatoes when applied dry or watered on the soil previous to sowing.

10. *Zinc Oxide* (ZnO).

Zinc oxide has been recommended by Horsfall (14) both for the treatment of seeds and for the treatment of soil previous to sowing and after damping-off has already appeared.

For soil treatment it is applied at the rate of $\frac{1}{2}$ oz. per sq. ft., or 3 lbs. per each 100 sq. ft., dusted evenly over the surface of the soil after the seeds have been covered. It may also be applied after the seedlings have appeared.

Some seedlings are apparently susceptible to injury by the zinc oxide hence the treatment should not be used indiscriminately. As a preventive of post-emergence damping-off it has now been largely superseded by cuprous oxide applied as a spray.

11. *Permanganate of Potash* (KMnO_4).

Permanganate of potash is a popular remedy among gardeners for the control of damping-off. It is used, for instance, with success in the Edinburgh Botanic Gardens.* Directly damping-off occurs in the smallest degree all the beds and seed boxes are watered with a solution at the rate of 1 oz. in 4 gallons of water (a rosy pink solution). If the fungi have got a good hold a solution of 1 oz. to 2 gallons is used.

In America (19) it is commonly used at the rate of 1 in 1,000 or 1 oz. in 30 quarts of water, applied to cuttings after they have been inserted in sand. Tests carried out by Horsfall (15) indicated that it has distinct fungicidal value, but that its effects are too fleeting.

12. *Sulphuric Acid* (H_2SO_4).

Sulphuric acid has been found to be valuable in the treatment of nursery beds of conifers against damping-off (26). It persists for some time in the soil and also kills seeds of weeds. It has the disadvantages of difficulty of application, and uncertain action in certain soils and to certain plants, *e.g.* *Picea excelsa*. The amount used is $\frac{3}{16}$ to $\frac{5}{8}$ of an ounce of the commercial acid to each square foot at the time of sowing the seed. The beds are then watered very heavily. Sulphuric acid is apparently injurious to most vegetables and flowers.

13. *Acetic Acid* (CH_3COOH).

Acetic acid has been found to control successfully damping-off of pine seedlings, used at the rate of $1\frac{1}{2}$ pints of 0.8% acid per square foot after sowing. It is, however, toxic to most other seeds. Doran (7, 8) found it efficient in controlling damping-off fungi in seed-beds when applied at a concentration of 1%, at the

*Information kindly supplied by Mrs. N. L. Alcock.

rate of $\frac{1}{2}$ gallon per square foot, from 7 to 14 days previous to sowing. Cucumber, tomato, lettuce and white spruce were thereby protected against injury by damping-off during and after seed germination. It is highly injurious to growing plants, although the fumes from treated soil will not injure neighbouring plants in well-ventilated greenhouses. Horsfall (15) found 3% acetic acid injurious when applied in the field to peas after sowing.

14. *Cresylic Acid.*

Commercial cresylic acid (straw-coloured liquid carbolic acid) contains 97–99% of a mixture of ortho-, meta- and para-cresols, and small quantities of phenol. (24).

It is largely used by greenhousemen for soil sterilization in place of steaming, there being several proprietary preparations on the market. It penetrates into the soil, however, very feebly, is of little value as a fungicide, and is highly toxic to plants. It is usually employed at a dilution of about 1 in 40 in water, the solution being applied at the rate of about 2 to 4 gallons per square yard. Treated soil must be left about a month before sowing. Bewley (3) has shown that even when the fungicide is applied very efficiently to greenhouse soils the resulting yield of tomatoes is much inferior to that resulting after steaming or formalin sterilization.

15. *Pyroligneous Acid.*

Pyroligneous acid, at the rate of 3 to 4 per cent., has been successfully employed in the United States (7) against damping-off of vegetables. It is used at the rate of 2 quarts per square foot of soil. Pyroligneous acid is not a chemical compound, but contains a mixture of acetic acid, methyl alcohol, formaldehyde and furfural, and its active constituents are not known. It is relatively cheap.

16. *Formaldehyde (H.CHO).*

Formaldehyde has long been known as a very efficient soil fungicide. It is sold in aqueous solution as formalin, a colourless liquid with an approximate strength of 40 per cent. The usual recommendation for the partial sterilization of greenhouse soil is to add 1 gallon of formalin to 49 gallons of water, and to water the soil with this solution at the rate of $\frac{1}{2}$ to $1\frac{1}{2}$ gallons per sq. foot, one ton of soil requiring about 40 gallons of diluted formalin. The soil is covered with sackings or a tarpaulin for 48 hours after treatment and is safe to use when all smell of the vapour has gone. This is usually not till about a fortnight after the treatment.

The effectiveness of formaldehyde is mainly due to its high penetration. It also leaves no deleterious residues in the soil, but has the disadvantage of taking some time to become dissipated. It is said to be ineffective against *Botrytis*, and Kadow (16) has found that Crucifers are especially liable to be injured by it. Again, the gas is said to form some injurious compound in the presence of lime, hence in the case of soils of high lime content a small test of its effectiveness should first be carried out.

The formalin solutions have the effect of puddling the soil and as an alternative Guterman and Massey (11) suggest using very little water. They recommend $2\frac{1}{2}$ tablespoonfuls of formalin, diluted with 5 or 6 parts of water, per bushel of soil, or 1 tablespoonful (about 15 cc.) per flat. The formalin is mixed thoroughly with the soil which should stand 12 to 24 hours before sowing. If only 6 to 9 cc. are used per flat the seeds may be sown at once. The soil must be watered thoroughly after sowing.

Considerable success has also been obtained in the United States by incorporating the formaldehyde, at the rate of 6 per cent., in a dry carrier such as sawdust, charcoal, infusorial earth, kaolin or peat moss (1). Several such proprietary preparations are on the market. The dust is mixed with the soil to be sterilized at the rate of about $1\frac{1}{2}$ oz. per sq. foot, preferably at least 24 hours before sowing. Most seeds may be sown safely in this soil provided it is watered immediately afterwards.

Recently very interesting results have been obtained by Haenseler (12) with very dilute solutions of formaldehyde, watered on the soil immediately after the seeds are sown, and, as will be seen below, these dilute solutions also gave excellent results in our own experiments.

Horsfall (15) also found that 1 in 150 formalin applied as a drip gave greatly increased germination of peas in the field and of beet seedlings in a greenhouse.

17. *Ammonium Hydroxide* (NH_4OH).

Ammonia has been used as a soil fungicide by Osmun (21), who applied it at dilutions ranging from 1 in 30 to 1 in 60, at the rate of 2 quarts per square foot, two weeks before sowing the seed. Some control was obtained in certain cases, but there was a tendency to injury.

18. *Bleaching Powder* (Chloride of Lime, CaOCl_2).

The active principle of bleaching power is chlorine gas, of which it should contain 33% to be of standard efficiency.

Horsfall (15) tested certain hypochlorites and found them without appreciable effect on either pre-emergence or post-emergence damping-off.

Experimental.

In order to assess the value of a number of chemicals as soil disinfectants these were applied to soil in seed boxes either prior to or after sowing a known number of peas. The boxes were approximately 1 sq. ft. in area and 2 in. deep. The soil was a greenhouse compost, which was very well mixed to secure uniformity. The seeds used were peas of the variety Early Bird, unless otherwise stated. 60 seeds were sown per box, there being two boxes for each treatment.

Chemicals applied in solution, or in suspension in water, were watered on by means of a watering can. It was usually necessary to apply a small amount of water to the soil previously in order to bring it into a good physical condition for penetration. In all cases the boxes were again watered lightly after application of the chemical solutions.

Dry chemicals were mixed thoroughly, in weighed amounts, with the soil from the boxes.

The chemicals were applied at the dilutions and rates found to be most effective by previous workers. Some had to be applied a long time previous to sowing, others immediately before, while some were applied just after sowing.

The sections which follow describe the procedure in the case of the separate experiments, while the tables at the end of the paper indicate the results of the experiments. In Column 1 of each table the number indicates the order of the chemical in the descriptive list given above.

Experiment 1.

In this experiment Nos. 13, 15, 16 and 18 were applied 18 days before sowing and the soil was watered after sowing. The other treatments were applied after sowing the peas and the boxes were watered lightly after sowing. The peas were sown on November 15, 1937, and took about 10 days to emerge.

The percentage germination in the control boxes was 50, so that the experiment may be relied on as giving a good indication of the effectiveness of the various treatments.

The best results were given by formalin 1-50, applied 18 days before sowing, followed by No. 16c, a proprietary fungicide in powder form, in which the formaldehyde is adsorbed on sawdust. Formalin 1-200 applied directly after sowing also gave good results, as did acetic acid 1-100.

Experiment 2.

In this experiment there were included three proprietary organic mercurials, Nos. 3A, 3B, and 3C. These were applied at the rates recommended by the manufacturers. There were also included two proprietary non-mercurial fungicides, Nos. 19A and 19B, said to be of value in the case of certain damping-off diseases.

Treatments 3A, 13, 15, 16A, 17 and 18 were applied a fortnight before sowing, while treatments 1, 2, 4, 5, 6, 9, 11 and 12 were applied a week before sowing. No. 16c was applied two days before sowing, while Nos. 19A and 19B were applied immediately before sowing. The following were applied immediately after sowing: 16B, 3B, 3C. All the boxes were watered lightly after sowing. The seeds were sown in mid-December, 1937.

The average germination of the control boxes was 80%, so that the test was not an extremely valuable one. The best results were given by ammonia, organic mercury B, non-mercurial B, adsorbed formalin and formalin at 1-50 and 1-300, all these results coming close together.

Experiment 3.

In this experiment the variety Surprise was used instead of Early Bird.

No. 14, cresylic acid, was applied seven weeks before sowing. It was first emulsified by mixing 50 cc. of the acid with 20 cc. oleic acid and adding 800 cc. water containing 30 cc. of 10% sodium hydroxide, the resulting emulsion being made up to 2000 cc.

The following were applied a fortnight before sowing, No. 3A, 13, 15, 16A, 17; 16c was applied a day before sowing; 19A and 19B were applied just before sowing, while 3B, 3C and 16B were applied immediately after sowing. All the boxes were watered lightly after sowing.

The seeds were sown on January 20th, 1938, and took about 10 days to emerge. The control boxes gave an emergence of only 28%, so that the test may be regarded as a satisfactory one. By

far the best results were given by the formalin treatments, all these giving an emergence of 93 and 94%. The next best was organic mercurial C with 82%.

Experiment 4.

In this experiment Cheshunt Compound was used at the rate of 1 in 320 or $\frac{1}{2}$ oz. per gallon, since in the previous experiments the dilution was stronger than that recommended by Bewley. This was compared with a proprietary form of cuprous oxide, stated to contain 55% cuprous oxide, and with zinc oxide, applied dry at the rate of $\frac{1}{2}$ oz. per sq. ft. There were also included ammonia at 1-40 and the formalin preparations which had previously given good results, namely 1-300, and a proprietary formalin adsorbed on sawdust. Nos. 10 and 16c were applied before sowing, the others after sowing.

Two varieties of peas were used, Surprise and Foremost, and there were two boxes of these, containing 50 seeds each in each treatment. All the boxes were watered slightly before and after treatment.

The percentage germination of the peas in the control boxes amounted to 88 and 73 for the two varieties. The only treatments giving at all satisfactory results were the two formalin treatments, which exceeded these, except in the case of the adsorbed formalin on the variety Foremost, which gave a low germination.

Experiment 5.

In view of the very satisfactory results obtained both with strong and weak formalin solutions, the latter applied after sowing, a series of trials was run with formaldehyde solutions ranging from 1-100 to 1-600, the rate of application being 750 cc. per box. The variety of pea was Early Bird. The control boxes gave an emergence of 68%, while the treated boxes between 1-200 and 1-600 gave an emergence between 84 and 90%.

Experiment 6.

Boxes of soil sown with cucumbers, tomatoes, sweet peas (50 per box) and stocks (100 per box) were treated with formalin 1-300.

It will be seen that considerably increased germination was given with cucumber, tomato and sweet pea, but in the case of stocks the germination was reduced.

Post-emergence damping-off occurred later among the cucumbers in the untreated box, but not in the treated.

Experiment 7.

In a further experiment sowings were made of ten kinds of ornamentals and some of the boxes were treated immediately afterwards with 1-300 formalin solution at the rate of 750 cc. per box. There was an average of 500 seeds per box. Germination was reduced in the case of antirrhinum, poppy and wallflower and markedly increased only in the case of marigold (calendula).

Conclusion.

The results of the above experiments indicate that, of the large number of chemicals tested, formaldehyde is the most efficient as a soil fungicide against the fungi causing damping-off, and that, as already indicated by Haenseler (12), if used at dilutions of 1-200 to 1-600 for watering seed boxes after the seed has been sown, it controls damping-off fungi to a marked extent. It was used successfully with seeds of peas, tomatoes, cucumbers and sweet peas, but apparently caused injury to seeds of stocks and certain other ornamentals.

EXPERIMENT 1.

No.	Treatment.	Dilution.	Rate of Application. (per box)	% Emergence.
4	Copper sulphate	1-250	500 cc.	39
5	Copper carbonate	1-250	500 cc.	45
6	Cheshunt compound	7-500	500 cc.	37
9	Aluminium sulphate	1-50	500 cc.	23
11	Potassium permanganate	1-500	500 cc.	45
12	Sulphuric acid	1-100	500 cc.	42
13	Acetic acid	1-100	1,000 cc.	72
15	Pyroligneous acid	4-100	1,000 cc.	57
16	Formalin A	1-50	1,000 cc.	93
	" B	1-200	850 cc.	73
	" C (adsorbed)	dry	40 g.	80
18	Bleaching Powder	dry	5.5 g.	55
	Control	—	—	50

EXPERIMENT 2.

No.	Treatment.	Dilution.	Rate of Application (per box)	% Emergence.
1	Mercuric chloride	1—500	500 cc.	83
2	Mercurous chloride	1—500	500 cc.	73
3	Organic mercurial A	1—200	700 cc.	65
	" " B	1—200	700 cc.	90
	" " C	1—100	700 cc.	75
4	Copper sulphate	1—250	500 cc.	85
5	Copper carbonate	1—250	500 cc.	83
6	Cheshunt compound	7—500	500 cc.	80
9	Aluminium sulphate	1—50	500 cc.	82
11	Potassium permanganate	1—500	500 cc.	78
12	Sulphuric acid	1—10	500 cc.	77
15	Pyroligneous acid	4—100	1,000 cc.	75
16	Formalin A	1—50	1,000 cc.	88
	" B	1—300	750 cc.	88
	" C (adsorbed)	dry	35 g.	90
17	Ammonia	1—40	1,000 cc.	92
18	Bleaching powder	dry	5.5 g.	82
19	Proprietary non-mercurial A	dry	4 g.	78
	" " B	dry	4 g.	90
	Control	—	—	80

EXPERIMENT 3.

No.	Treatment.	Dilution.	Rate of Application (per box)	% Emergence.
3	Organic mercurial A	1—200	700 cc.	63
	" " B	1—200	700 cc.	27
	" " C	1—100	700 cc.	82
13	Acetic acid	1—100	1,000 cc.	37
14	Cresylic acid (emulsified)	1—40	1,000 cc.	65
15	Pyroligneous acid	4—100	1,000 cc.	68
16	Formalin A	1—50	1,000 cc.	94
	" B	1—300	750 cc.	93
	" C (adsorbed)	dry	35 g.	94
17	Ammonia	1—40	1,000 cc.	70
19	Proprietary non-mercurial A	dry	4 g.	18
	" " B	dry	4 g.	23
	Control	—	—	28

EXPERIMENT 4.

No.	Treatment.	Dilution.	Rate of Application (per box)	% Emergence.	
				Var. Surprise.	Var. Foremost.
6	Cheshunt compound ..	1—320	500 cc.	30	47
8	Cuprous oxide ..	1—320	500 cc.	37	47
10	Zinc oxide	dry	14 g.	56	60
16	Formalin B	1—300	750 cc.	95	92
	„ C (adsorbed) ..	dry	40 g.	99	65
17	Ammonia	1—40	1,000 cc.	6	31
	Control	—	—	88	73

EXPERIMENT 5.

No.	Treatment.	Dilution.	Rate of Application (per box)	% Emergence.
16	Formalin	1—100	750 cc.	68
	„	1—200	„	84
	„	1—300	„	90
	„	1—400	„	85
	„	1—500	„	87
	„	1—600	„	89
	Control	—	—	68

EXPERIMENT 6.

SOIL TREATED WITH FORMALIN 1—300 AFTER SOWING. PERCENTAGE EMERGENCE.

	Cucumber.	Tomato.	Sweet Pea.	Stock.
Box 1 ..	98	78	64	30
„ 2 ..	94	76	62	24
„ 3 ..	96	58	50	20
„ 4 ..	92	62	70	36
Average ..	95	68	61	27
SOIL UNTREATED.				
Box 1 ..	88	50	44	32
„ 2 ..	76	66	42	40
„ 3 ..	74	58	58	56
„ 4 ..	76	62	46	58
Average ..	78	59	47	46

EXPERIMENT 7.

TREATED WITH FORMALIN AFTER SOWING. PERCENTAGE EMERGENCE.

<i>Type of Seed.</i>	<i>Formalin Treated.</i>	<i>Control.</i>
Antirrhinum	0.5	19
Cosmos	39	33
Eschscholtzia	32	36
Lobelia	36	37
Marigold (Calendula)	42	19
Poppy	8	13
Salpiglossis	22	23
Wallflower	22	38

REFERENCES.

- (1) ALEXANDER, L. J., YOUNG, H. C. and KIGER, C. M. The Causes and Control of Damping-off of Tomato Seedlings. *Ohio Agr. Expt. Stn. Bull.*, 496, 1931.
- (2) BEWLEY, W. F. Control of Damping-off and Foot Rot of Tomatoes. *Journ. Min. Agr.*, 28, pp. 653, 654, 1921.
- (3) BEWLEY, W. F. Practical Soil Sterilization. *Min. Agr. Bull.*, 22, 1935.
- (4) CLAYTON, E. E. Investigations of Cauliflower Diseases on Long Island. *N. Y. (Geneva) Agr. Expt. Stn. Bull.*, 506, 1924.
- (5) CUNNINGHAM, G. H. Plant Protection by the Aid of Therapeutics. *New Zealand*, 1935.
- (6) DAHL, A. S. Snowmould of Turf Grasses as Caused by *Fusarium nivale*. *Phytopathology*, 24, pp. 197-214, 1934.
- (7) DORAN, W. L. Acetic Acid as a Soil Disinfectant. *Journ. Agr. Res.*, 36, pp. 269-280, 1928.
- (8) DORAN, W. L. Acetic Acid and Pyroligneous Acid in Comparison with Formaldehyde as Soil Disinfectants. *Journ. Agr. Res.*, 44, pp. 571-578, 1932.
- (9) DORAN, W. L. Germination of Seeds and Damping-off and Growth of Seedlings of Ornamental Plants as affected by Soil Treatments.* *Mass. Agr. Expt. Stn. Bull.*, 351, 1938.
- (10) GLOVER, W. O. and GLASGOW, H. Cabbage Seedbed Diseases and Delphinium Root-rots. Their Relation to certain Methods of Cabbage Maggot Control. *N. Y. State Agr. Exp. Stn. Bull.*, No. 513, 1924.
- (11) GUTERMAN, C. E. F. and MASSEY, L. M. A liquid Formaldehyde Treatment to Control Damping-off of Flower Seedlings. *Phytopathology*, 25, p. 18, 1935.

*This interesting paper was unfortunately received too late for review.

- (12) HAENSELER, C. M. Damping-off of Seedlings Controlled by new Method of using Formaldehyde. *Agric. News Lett.*, 3, 5, pp. 7, 8, 1935. (*R. A. M.*, 14, p. 671, 1935).
- (13) HORSFALL, J. G., NEWHALL, A. G. and GUTHERMAN, C. E. F. Dusting Miscellaneous Seeds with Red Copper Oxide to Combat Damping-off. *N. Y. State Agr. Expt. Stn. Bull.*, 643, 1934.
- (14) HORSFALL, J. G. Zinc Oxide as a Seed and Soil Treatment for Damping-off. *N. Y. State Agr. Expt. Stn. Bull.*, 650, 1934.
- (15) HORSFALL, J. G. Combating Damping-off. *N. Y. State Agric. Expt. Stn. Bull.*, 683, 1938.
- (16) KADOW, K. J. and ANDERSON, H. W. Damping-off Control. An Evaluation of Seed and Soil Treatments. *Univ. Illinois Agr. Expt. Stn. Bull.*, 439, 1937.
- (17) MARTIN, H. The Scientific Principles of Plant Protection. *London, Ed. Arnold and Co.*, 1936.
- (18) MONTEITH, J. and HARMON, T. C. Fungicidal Control of Brown Patch of Turf. *Abstract in Phytopathology*, 17, p. 50, 1927.
- (19) NEWHALL, A. G. and CHUPP, C. Soil Treatments for the Control of Diseases in the Greenhouse and Seed Bed. *N. Y. State Coll. Agr. Bull.*, 217, 1931.
- (20) OGILVIE, L. and HICKMAN, C. J. Cuprous Oxide and Zinc Oxide as Seed Protectants. *Gard. Chron.*, 103, pp. 79-80, 1938.
- (21) OSMUN, A. V. *Rept. Mass. Agr. Expt. Stn.*, 1934, pp. 23, 27, 1935. (*R. A. M.* 14, p. 683, 1935).
- (22) PIRONE, P. P., NEWHALL, A. G., STUART, W. W., HORSFALL, J. G. and HARRISON, A. L. Copper Seed Treatments for the Control of Damping-off of Spinach. *Cornell Univ. Agri. Exp. Stn. Bull.*, 566, 1933.
- (23) PRESTON, N. C. Experiments on the Control of Finger and Toe in Cabbages by the Use of Mercuric Chloride and other Substances. *Welsh Journ. Agric.*, 4, pp. 280-295, 1928.
- (24) RUSSELL, E. J. and PETHERBRIDGE, F. R. Partial Sterilization of Soil for Glasshouse Work. *Journ. Bd. Agr.*, 19, pp. 809-827, 1913.
- (25) THOMAS, H. E. Some Chemical Treatments of Soil for the Control of Damping-off Fungi. *Phytopathology*, 17, pp. 499-506, 1927.
- (26) WIANT, J. S. Rhizoctonia Damping-off of Conifers and its Control by Chemical Treatment of the Soil. *Cornell Univ. Agric. Expt. Stn. Mem.*, 124, 1929.

A ROOTSTOCK CANCER OF HOPS CAUSED BY GIBBERELLA PULICARIS (FR.) SACC.

By D. L. G. DAVIES.

The prevalence and severity of a rootstock canker of the hop (*Humulus Lupulus*) was a matter of concern to many hop growers in the Tenbury Wells districts of Worcestershire in 1938. According to some growers, this disease, which came into particular prominence some three years ago, has resulted in a total loss of hop plants in many yards.

The Disease.

Rootstock canker of hops was first described by Percival in 1902 (3) and the disease attributed to the fungus *Fusoma parasiticum* Tub. (= *F. oxysporum* Schl. var. *aurantiacum* (Lk.) Wr.).

Salmon and Wormald writing in 1922 state that "hop canker has been known for the past thirty or forty years, if not longer. It is known generally in Kent, Sussex, Surrey, Hampshire, Herefordshire and Worcestershire as 'canker,' but in many districts of the Weald of Kent and of Sussex farmers, as well as foremen in the hop gardens, give the disease the descriptive name of 'growing-off.'"

The disease was given the name "rootstock canker" by Salmon and Ware (7) so as to distinguish it from "bine canker," a canker of the lower part of the hop stem or bine some distance above soil level, the extreme base of the stem being unaffected. Both these diseases were attributed to fungi of the genus *Fusarium* with which their perfect stage, *Gibberella* sp., was associated. The disease appears to occur widely throughout Europe and also in New Zealand.

Symptoms of the Disease.

The symptoms of rootstock canker are described by Salmon and Wormald (6) as follows: "Above ground the presence of the disease is indicated by the wilting of one or more bines at each affected 'hill'; such bines are found to be almost severed at the

base and easily come away from the rootstock with a slight pull, a condition which, as noted above, is sometimes described by growers as 'growing-off' of the bines. This wilting of the bines is accompanied by a canker of the underground rootstock, the infected portions being brown and dead."

It is the opinion of Ogilvie and the writer that a pale green colour of the leaves accompanied by a mosaic-like puckering are also symptoms frequently shown by infected plants.

The Distribution of Diseased Plants in certain Hop Yards.

The writer investigated a number of infected hop yards during a brief stay near Tenbury Wells in June, 1938. The conditions of four widely separated yards were as follows:—

Case No. 1. The owner of this yard stated that the disease became noticeable three years previously, following a succession of wet winters. The estimated loss of plants in 1937 was 10%, whilst the loss in 1938 was put at 60 to 70%. Infected plants were distributed throughout the yard, and the disease symptoms were identical with those described by Salmon and Wormald.

Case No. 2. On this farm there were two hop yards separated by the main road from Tenbury Wells to Eardiston, which runs approximately east and west.

The yard on the south side of the road was bordered on the south by the river Teme. It had been replanted five years previously after a severe attack of "nettlehead," probably a virus disease, and the plants were perfectly healthy and free from canker. According to the grower this yard was well drained into the river.

The northern yard was bounded on the north by a range of low hills. It had been planted for fifteen years and was very severely infected with canker, very few plants being healthy. According to the grower this yard was subject to periodic flooding from the neighbouring hilly ground, and the drainage of the yard was insufficient to cope with the excess of water.

Case No. 3. This yard was 10 to 15 acres in area and was badly infected with canker. Although bounded on the south by the river Teme, the land sloped in the opposite direction and drainage was not satisfactory. The field was severely and uniformly infected.

Case No. 4. Plants growing in one corner of this yard were severely cankered, although infected plants occurred throughout the yard. The grower stated that the affected corner of the yard had been subject for many years to flooding during wet weather, and this was found to be due to the drains at that point being unconnected with a main drain, with the result that the water came to the surface. Although the defective drainage had been rectified hop plants at this point remained unhealthy.

The observations in these four cases appear to indicate that defective drainage tends to increase the amount of hop canker, though it is well known that well drained soil favours hop cultivation and waterlogging is detrimental to the plants.

Salmon and Wormald (6) also state that "while by no means confined to hop-gardens on heavy, wet soils, the disease does appear to be favoured by moist conditions. The general experience of hop-growers is that 'canker' is worse in a wet season or following a wet winter." As a specific instance Salmon and Ware (8) state that canker was unusually prevalent in Kent in 1936, possibly owing to the preceding very wet winter.

The Causal Organism and Mode of Infection.

Salmon and Wormald (6) found that a species of *Fusarium* was associated with rootstock canker, masses of spores occurring on the bases of diseased bines and mycelium in the discoloured tissue of the straps.

Salmon and Ware (7) reported the presence of *Fusarium* spores on the bines and on infected straps lying on the ground. Sometimes on grubbed-up rootstocks a dark bluish-purple fungus (*Gibberella* sp.) was also found. This was thought to be the perfect stage of the parasitic *Fusarium*. The *Gibberella* had been first found on hop material in this country by W. F. Cheal in 1923 (1), and it was obtained in culture at Wye and East Malling Research Station.

These cultures resembled those of the *Fusarium* which had been found to be associated with canker, but Salmon and Ware state that "inoculation experiments to prove the pathogenicity of either or both of the stages of the fungus have not been made in this country."

The above workers (7) also stated that Dr. J. Feltgen found a variety of the fungus *Gibberella Saubinetii* on dead stems of hops at Luxemburg in 1903 and named this fungus *Gibberella Saubinetii* var. *tetraspora*, since each ascus contained but four spores. A

species of *Gibberella* was also discovered in France in 1928 by J. Millasseau (2) on certain English hop sets, and was identified as *Gibberella Saubinetii*.

Wollenweber and Reinking report in their monograph, "Die Fusarien" (9), p. 210, that Curtis investigated a "black rot" disease of hops in New Zealand and identified the causal organism as *Gibberella pulicaris* (Fr.) Sacc. var. *minor* Wr., of which the conidial stage is *Fusarium sambucinum* Fuck. f.I Wr. They also suggest that *Gibberella pulicaris* (Fr.) Sacc., of which the conidial stage is *Fusarium sambucinum* Fuck., may be the cause of hop canker in Europe, though they state that satisfactory inoculation experiments had not been carried out.

Diseased hop material consisting of infected straps, collected by the writer in 1938 at the four localities already described and also at a place near Pershore, Worcestershire, were found to bear perithecia of a species of *Gibberella*. Most of these diseased straps arose from crowns which were perfectly healthy, but the bines arising from the straps were all cankered at their bases and bore mycelium and masses of spores of a *Fusarium*. This *Fusarium* was obtained in culture, and after a period of two months produced perithecia of a species of *Gibberella* on the surface of the culture medium.

Perithecia found on diseased straps in the hop yard were situated invariably near the cut end of the strap (see Fig. 1). In order to trace the origin of these cut ends, it is necessary to refer to methods employed in the cultivation of the hop plant (1).

"The hop is propagated on a commercial scale by means of cuttings, and cuttings are usually of two kinds—either straps from aerial shoots of the previous season, or from underground stems or runners. The straps consist of the lowest 6 or 8 inches of the stem attached to the rootstock, which have been earthed up in summer and swollen by the downward passage and accumulation of plant-food in late summer."

At the end of the season, in order to keep the "hills," i.e. the individual plants, in their place and to prevent straggling, two parts of the plant are cut—the straps of the crown and the runners—although many growers in Worcestershire cut the straps only.

The strap shown in illustration was taken from the crown of a well-developed plant which was diseased, the cut end of the strap resulting from the cutting away of a bine some time previously. The frequency with which perithecia occur near such a cut surface

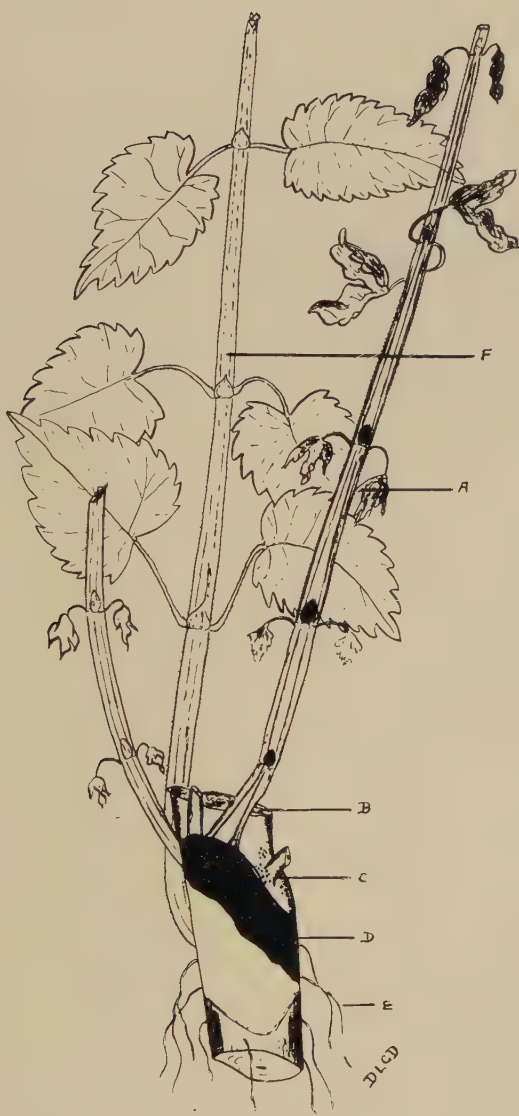


FIG 1.—Part of a Hop Plant infected with Canker.
($\frac{1}{2}$ Natural Size).

- A. Wilted Bine.
- B. Cut End of Strap.
- C. Perithecia of *Gibberella pulicaris*.
- D. Infected Strap cut longitudinally to show Discolouration of Wood.
- E. Rootlets from Base of Strap.
- F. Healthy Bine arising from below infected Area.

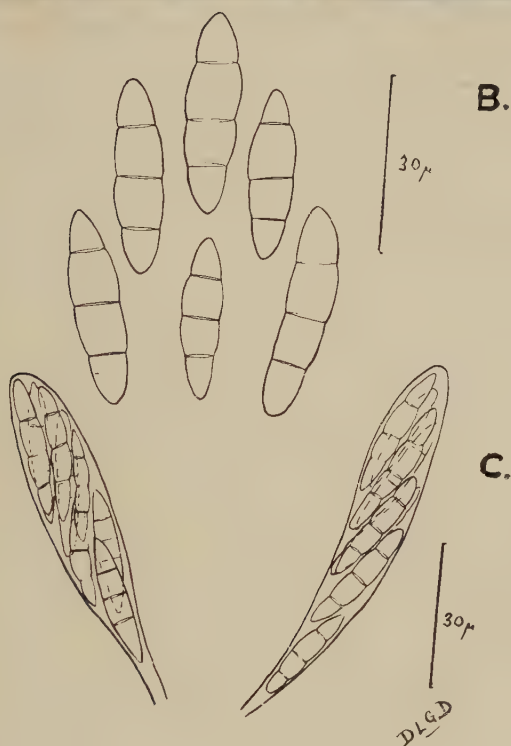
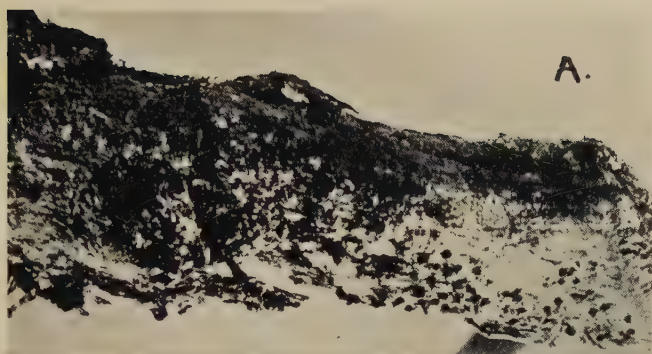


FIG. 2.

- A. Perithecia of *Gibberella pulicaris* on a diseased Hop Strap from Worcestershire.
- B. Ascospores of *Gibberella pulicaris*.
- C. Asci of *Gibberella pulicaris*.

strongly suggests that the fungus enters the plant through these wounds and penetrates downwards into the crown.

New bines arise from the remaining portions of cut straps and the number of bines infected on each strap corresponds to the distance which the fungus has progressed down the strap. An examination of severely infected plants reveals the crowns and roots to be frequently free from attack, the infection being restricted to portions of straps bearing new bines.

In their paper on hop canker, Salmon and Wormald (6) state "Where the straps were not wholly destroyed the decay in every case was at the lower end, the upper end being still alive and bearing shoots. This indicates that the disease spreads from the crown of the rootstock into the straps."

In the course of the investigation made by the writer, a large number of hop plants bearing diseased bines were removed from the soil. The majority of bines cankered at their bases were borne on straps which were completely infected or else infected at their upper ends only. In no case was a strap found to be infected at the lower end and bearing healthy shoots on the upper, unaffected end.

It is possible that infection may spread from the crown, but in the cases investigated by the writer, infection apparently originated at the cut ends of the straps.

As stated above, the *Fusarium* isolated from diseased bines produced in culture perithecia of a *Gibberella* identical with those found on diseased straps at the bases of these bines. A study of the morphological features of the fungus has shown it to be identical with *Gibberella pulicaris* (Fr.) Sacc. of which the imperfect stage is *Fusarium sambucinum* Fuck.

The Morphological Features of the Fungus.

The morphological features of the perithecia obtained from diseased hop straps are as follows:—Perithecia in irregular heaps, or scattered and solitary on a brown stroma, 0.30×0.23 mm. (0.22 — 0.42×0.16 — 0.30 mm.), globose, conoid or ovoid, black. Wall violet-blue to dark violet-blue by transmitted light, wrinkled and warted when dry. Ostium papillate.

Asci clavate, almost sessile, 73 — 105×12 — 15 μ . Apex rounded.

Ascospores obliquely uniseriate and biseriate, oblong-oval or fusoid, straight or curved, three-septate, hyaline, smooth, slightly constricted at the septa, 24×5.9 μ (21 — 28×5 — 6 μ).

These morphological characteristics indicate the fungus to be *Gibberella pulicaris* (Fr.) Sacc. and this finding was kindly confirmed by Drs. H. W. Wollenweber and T. Petch, and Mr. W. C. Moore.

Gibberella pulicaris (Fr.) Sacc. is described by Petch (4) as follows:—

“*Gibberella pulicaris* (Fr.) Sacc. in *Michelia*, I, (1877) 43; *Sphaeria pulicaris* Fr. in Kunze and Schm., *Mycol.*, Hfte. 11. (1823), 37.

Perithecia caespitose in pulvinate or irregular heaps on a brown stroma, or scattered and solitary, up to 0.3 mm. diameter, globose, conoid, or ovoid, collapsing, at first rufous, then appearing black, but the wall dark violet-blue by transmitted light, rugose, wall leathery, wrinkled and appearing warted when dry, ostium minute, papillate; asci subcylindrical or clavate, almost sessile, $75-105 \times 11-15 \mu$, apex at first truncate, becoming rounded, spores obliquely uniseriate or biseriate; ascospores oblong-oval or narrow-oval, sometimes fusoid, inequilateral, straight or curved, ends rounded, three septate, hyaline, smooth, slightly constricted at the septa, $16-24 \times 6-9 \mu$.

On branches and stems of woody and herbaceous plants. Generally distributed. On elder, broom, and Brassica stalks, North Wootton. On Pteris, Lyndhurst, August 1885, Hb. Kew.”

The fact that *Gibberella pulicaris* occurs on woody and herbaceous plants is interesting in so far as it may account for the origin of the infection of the hop yards.

Single ascospores of the fungus were transferred to various culture media and produced the imperfect stage of *Gibberella pulicaris* which is *Fusarium sambucinum* Fuck.

The morphological and cultural characteristics of *Fusarium sambucinum* which have been noted up to the present, are as follows:—

On Malt-extract Agar.

Fairly abundant aerial mycelium, white to salmon colour. (5).
Substratum carmine to orange citrine to mummy brown.

Spore Measurements.

0	Septate	($11.0 \times 3.0 \mu$)	few.
1	„	($16.0 \times 3.0 \mu$)	2%, ($13-20 \times 2.8-3.2 \mu$).
2	„	($20.8 \times 3.4 \mu$)	2%, ($18-24 \times 3.0-3.5 \mu$).
3	„	($26.6 \times 3.7 \mu$)	36%, ($21-30 \times 3.5-4.5 \mu$).
4	„	($30.2 \times 4.0 \mu$)	30%, ($25-36 \times 3.5-4.5 \mu$).
5	„	($35.5 \times 4.7 \mu$)	30%, ($33-42 \times 3.5-5.0 \mu$).

On Wheatmeal Agar.

Scanty aerial mycelium, white to shrimp pink. Spores in pionnotes shell pink in mass.

Substratum carmine to ox-blood red.

Spore Measurements.

2	Septate	(25.0 × 3.2 μ)	2%,	(20—24 × 3.0—3.5 μ).
3	„	(28.3 × 3.4 μ)	36%,	(24—33 × 3.0—4.0 μ).
4	„	(32.0 × 3.9 μ)	31%,	(24—38 × 3.5—4.5 μ).
5	„	(37.0 × 4.0 μ)	31%,	(34—40 × 3.5—5.0 μ).

On Oatmeal Agar.

Scanty aerial mycelium, pale persian lilac to pale purplish vinaceous. Spores in pionnotes shell pink.

Substratum carmine to ox-blood red.

Sclerotia white to pale pinkish buff 3—6 mm. diameter.

Spore Measurements. Spores from pionnotes.

1	Septate	(17.6 × 3.0 μ)	2%,	(15—21 × 2.9—3.2 μ).
2	„	(21.7 × 3.2 μ)	2%,	(18—28 × 3.0—4.0 μ).
3	„	(27.4 × 3.4 μ)	36%,	(21—33 × 3.0—4.0 μ).
4	„	(32.0 × 4.0 μ)	31%,	(25—36 × 3.5—4.5 μ).
5	„	(34.5 × 4.2 μ)	29%,	(31—39 × 3.5—5.0 μ).

Average of above measurements :—

0	Septate	(11.0 × 3.0 μ)	few.	
1	„	(16.8 × 3.0 μ)	2%,	(13—21 × 2.8—3.2 μ).
2	„	(22.5 × 3.3 μ)	2%,	(18—28 × 3.0—4.0 μ).
3	„	(27.4 × 3.5 μ)	36%,	(21—33 × 3.0—4.5 μ).
4	„	(31.4 × 4.0 μ)	30%,	(24—38 × 3.5—4.5 μ).
5	„	(35.3 × 4.3 μ)	30%,	(31—42 × 3.5—5.0 μ).

Wollenweber (9) gives the following spore dimensions for *Fusarium sambucinum* :—

3	Septate	(27 × 4.7 μ),	(23—33 × 3.5—5.2 μ).
5	„	(34 × 5.0 μ),	(26—42 × 3.8—5.6 μ).
7	„	(42 × 5.2 μ),	(35—56 × 3.7—6.0 μ).

It may be stated here that in his recent monograph on British Hypocreales (4) Petch differentiates *Gibberella pulicaris* (Fr.) Sacc., *G. cyanogena* (Desm.) Sacc., and *G. Zeae* (Schw.) Petch.

G. pulicaris occurs “on branches and stems of woody and herbaceous plants” and in the opinion of the present writer is the fungus probably mainly implicated in hop canker, at least in England.

G. cyanogena occurs on decaying herbaceous stems, while *G. Zeae* is the causative fungus of "scab" of cereals, which had been previously referred to *G. Saubinetii*. The imperfect stage of *G. Zeae* is *Fusarium graminearum* Sewabe.

The Production of Perithecia of *Gibberella pulicaris* under artificial Conditions.

Barley grains were sterilized in an autoclave and partly embedded in moist, sterilized sand in sterile petri dishes. These grains were then inoculated with mycelium from monospore cultures of *Fusarium sambucinum* and a *Fusarium* isolated from diseased hop bines, by placing a little mycelium on each grain. The petri dishes were then kept at room temperature.

After a period of six weeks, numerous perithecia were observed on almost every inoculated grain. Perithecia formed on grains inoculated with the *Fusarium* isolated from bines were found to be identical with perithecia of *Gibberella pulicaris*.

Pathogenicity Trials.

Forty cuttings of hop runners, three inches long and bearing shoot buds and roots, were placed in an upright position in 6 inch pots containing sterilized soil, four cuttings per pot.

Twenty cuttings were inoculated by placing mycelium of a monospore culture of *Fusarium sambucinum* and ascospores from perithecia of *Gibberella pulicaris* on the uppermost cut surface, the remaining cuttings serving as controls. All the cuttings were completely covered with soil, and the pots were then placed in the greenhouse.

Observations made up to the present have revealed a browning of the cutting tissues extending downwards from the inoculated surface, through the entire cutting. Four weeks after inoculation perithecia were observed to have formed on the inoculated surfaces.

As a result of the low temperature conditions and short days of the autumn months shoot growth was retarded, but shoots up to two inches in length developed and eventually wilted owing to the infection of the cutting.

Portions of infected tissue from the centre of diseased cuttings were transferred to petri dishes of malt-extract agar and the fungus *F. sambucinum* was recovered.

It therefore appears most probable that, in the cases described, hop canker is caused by the fungus *Fusarium sambucinum* which forms its perfect stage *Gibberella pulicaris* on the surface of infected hop tissues.

Summary.

1. A rootstock canker of hops, first described in 1902, seriously affected many hop yards in Worcestershire in 1938.
2. The symptoms of the disease are a wilting of the bines, brought about by rotting and canker of their extreme bases, and sometimes of the rootstock itself.
3. In the cases in question infection apparently originated at the cut ends of the "straps" (*i.e.* bases of bines of the previous season).
4. In the four cases investigated prevalence of the disease appeared to be associated with defective drainage.
5. Perithecia of *Gibberella pulicaris* (Fr.) Sacc. were commonly found on the ends of diseased "straps" and a *Fusarium* isolated from diseased material was shown to be *Fusarium sambucinum* Fuck., the conidial stage of the *Gibberella*. Perithecia of *G. pulicaris* were produced in culture.
6. Inoculation experiments have shown that in the cases in question the hop canker was due to the above fungus.

Acknowledgments.

The writer is indebted to Mr. L. Ogilvie for suggestions and advice, and to Drs. H. W. Wollenweber and T. Petch, and Mr. W. C. Moore, for confirming the identification of the fungus *Gibberella pulicaris* (Fr.) Sacc. Special thanks are due to Mr. A. R. Firkins, Eardiston, Wores., for hospitality during the investigation.

REFERENCES.

- (1) MINISTRY OF AGRICULTURE AND FISHERIES. "Cultivation, Diseases and Insect Pests of the Hop Crop." *Misc. Pubn.* No. 42, 1928.
- (2) MILLASSEAU, J. "Presence du *Gibberella Saubinetii* sur des Houblons atteints de 'Canker'." *Rev. Path. Veget. et d'Entomol. Agric.*, 15, 8, pp. 235-237, 1928.
- (3) PERCIVAL, J. *Journ. S.E. Agr. Coll., Wye*, 11, pp. 87-89, 1902.
- (4) PETCH, T. British Hypocreales. *Trans. Brit. Mycol. Soc.*, 21, 3 and 4, p. 280, 1938.
- (5) RIDGWAY, R. "Colour Standards and Nomenclature." 1912.
- (6) SALMON, E. S. and WORMALD, H. "Hop Canker or Growing Off." *Journ. Min. Agr.*, 29, pp. 354-359, 1922.
- (7) SALMON, E. S. and WARE, W. M. "An unusual form of Hop Canker." *Journ. S.E. Agr. Coll., Wye, Kent*, 28, pp. 62-64, 1931.
- (8) SALMON, E. S. and WARE, W. M. *Journ. S.E. Agr. Coll., Wye, Kent*, 39, pp. 22, 23, 1937.
- (9) WOLLENWEBER, H. W. and REINKING, O. A. "Die Fusarien," *Berlin*, 1935.

SPRAY INJURY STUDIES.
PROGRESS REPORT I.
SOME OBSERVATIONS ON THE PROBABLE
CAUSES OF LIME SULPHUR INJURY.

By W. E. BERRY.

INTRODUCTION.

The application of spray materials to the foliage of fruit plants is seldom unaccompanied by the risk of damage. The nature of the sprays used, containing as they must, substances toxic to the fungus or insect concerned, renders some risk almost inevitable, and it is generally difficult to reduce the phytocidal effect of the spray to a safe level without at the same time seriously impairing its protective value.

It is perhaps not surprising that injury occurs most frequently in the case of sprays containing very poisonous substances such as arsenic, when there is little doubt that the direct toxic effect of the chemical on the leaf protoplasm is responsible. Less obviously poisonous substances, however, in certain circumstances may produce profound effects on the foliage even at relatively high dilutions, and the immediate cause of the injury is by no means always apparent. Lime sulphur provides the outstanding example of this type of injury and displays in addition striking varietal effects, for whilst it may be applied with impunity even at high concentrations to some varieties of fruit plants, it may cause serious damage to closely related varieties even when very dilute.

The various types of lime-sulphur injury on apples have been described, with illustrations, by Young and Walton (28), by Wallace (25) and more recently by Jamalainen (11). Two different kinds of injury are common. Scorching of the leaves may occur, the tips and margins becoming brown and dry. This kind of injury is most common when the leaves are not fully opened, *i.e.* at the time of the first pre-blossom spray, and is most severe when frost follows the application. On fully developed leaves scorch takes

the form of brown necrotic patches, generally adjoining the larger veins and occurring mainly where the spray fluid has accumulated in patches on the leaf. This burning is attributed by Wallace (25), and by Young and Walton (28), to the penetration of soluble sulphides. On the other hand a very different effect may occur, particularly on sulphur sensitive varieties such as Lane's Prince Albert and Stirling Castle apples, and several varieties of gooseberry. In these cases, large numbers of leaves may be shed soon after the spray is applied and this may occur without any sign of scorch or other superficial injury, the fallen leaves appearing quite healthy.

Most apple varieties will stand lime sulphur as a pre-blossom spray at 3%, but beyond the pink flower stage marked varietal susceptibility becomes apparent. It will perhaps be of interest to enumerate here the relative susceptibilities of some of the common varieties grown at Long Ashton, though it will be clear from what follows that this classification will not necessarily apply strictly to other localities :—

Apples.

Worcester Pearmain Laxton's Superb Allington Pippin Rival.	}	May be sprayed with lime-sulphur at 1½% at any stage without damage.
Cox's Orange Pippin Bramley's Seedling Newton Wonder Charles Ross and some Cox crosses	}	Will stand a maximum strength of 1% lime sulphur.
Lane's Prince Albert Lord Derby Stirling Castle St. Cecilia.	}	Are extremely sensitive to sulphur and should on no account be sprayed with lime sulphur beyond the pink flower stage. The cider variety Foxwhelp is also included in this group.

Black Currants.

Davison's Eight and Taylor are very sulphur sensitive varieties. Some damage occurs on other varieties, particularly Edina, but this is not serious unless frost follows soon after spraying. It is common to apply lime sulphur at 1 in 12 or 1 in 20 to control Big Bud Mite when the leaves have reached "half-crown" size.

Gooseberries.

Early Sulphur (syn. Golden Drop)	}	Very susceptible.
Leveller		
Careless Crown Bob	}	Fairly sensitive.
Whinham's Industry White Lion		
Keepsake Lancashire Lad	}	Fairly tolerant.

Red Currants. All behave similarly and are fairly tolerant.

Pears. Generally tolerant, but Comice is quite sensitive.

Strawberries. All tolerant.

Raspberries. Are all more or less sensitive to sulphur.

Blackberries and Loganberries. Are fairly sensitive.

Plums. Are generally fairly tolerant except for the Gages and the variety Monarch, which are sensitive.

Apart from the wide differences between varieties, the possibility of injury varies considerably according to the concentration of the spray, the weather conditions prevailing about the time of application and the condition of nutrition of the plant. Much general information on these points has been accumulated somewhat fortuitously, but careful observations from controlled experiments appear to be lacking.

The Entry of Spray Materials into the Leaf.

Spray materials applied to the leaf surface may only enter the interior of the intact leaf and make contact with the protoplasm either (a) through the stomata, or (b) through the cuticle and epidermal hairs. In practice, however, many leaves have cuticles damaged by insect and fungus pests which renders the entry of spray less difficult.

There is no doubt that the stomatal pores of terrestrial plants, and the intercellular spaces below, can become injected with water

and aqueous solutions. Daxer (4) has discussed this possibility in relation to spray injury, and has suggested that cooling the leaves by the application of cold sprays to foliage in hot weather may result in a pressure deficit inside the leaf causing easy entry of spray fluid through the stomata. Such a means of entry would seem very likely provided the lower surface of the leaf were sufficiently wetted by the spray. This does not always occur in practice and is a matter for investigation with individual sprays. Where, however, volatile or gaseous constituents of the spray such as nicotine or hydrogen sulphide are present, there can be no doubt that to some extent these will enter the air spaces of the leaf by diffusion. When, as in the case of lime sulphur, a solid deposit is left by the evaporation of the spray, there is the further possibility that many of the stomata may be blocked, the normal gas exchange of the leaf interfered with and respiration and photosynthesis depressed.

The cuticle, covering the whole of the leaf surface except where it is perforated by stomatal pores, serves to reduce transpiration and preserve the leaf from desiccation. It is well known, however, that some loss of water occurs through the cuticle, and similarly, the passage of carbon dioxide into and out of the leaf can occur to some extent when the stomata are blocked. The cuticle is therefore not impermeable to water and gases, though the amount of its permeability normally accounts for but a small fraction of the total transpiration and gas exchange.

Wallace (24) and Mann and Wallace (14) have shown that considerable amounts of mineral substances, particularly potash, can be removed from the foliage-leaves of apple and other fruits by leaching with cold water. Arens (1) has recently reviewed the literature on cuticle permeability and has shown that when a drop of water is placed on a leaf surface, potassium, calcium, magnesium and to a less extent phosphate are excreted, giving an alkaline reaction to the water. He also detected the excretion of organic substances including phosphatides. This excretion is held to be a normal function of the leaf, whereby considerable amounts of dissolved substances are regularly eliminated to the moisture deposited on the leaf by rain or mist. The effect of spraying may well be to enhance this loss of solutes. It is equally clear on the other hand that if the cuticle is thus permeable to solutes lost from within, unless one way permeability is operative, spray materials may penetrate from outside. The entry of nutrient salts applied as sprays serves to illustrate this point. The intact cuticle being thus permeable, the possibility of penetration is increased enormously when we consider in how many leaves the cuticle is

perforated by fungoid or insect pests or weakened by weathering. As Arens (*loc. cit.*) has pointed out, repeated wetting no doubt alters the properties of the cuticle by saponification, so that its constitution, wettability and hence its permeability to sprays must change with the age of the leaf. Older leaves are more readily wetted by water, and Kamp (12) has shown that the cuticles of young leaves, though thinner, are less permeable to water than those of older leaves. Greater injury by pests no doubt accounts in a large measure for the shedding of older leaves when sulphur sensitive varieties are sprayed with lime-sulphur, but the above factors are probably also involved.

With regard to the leaf hairs, on apple leaves these are usually more numerous on the lower surface, in many varieties forming a thick mat. They have usually lost their contents and become filled with air. The hairs are relatively few on the upper surface and confined mainly to the main veins along which they may be fairly numerous. Partly due to the fewer hairs, but largely no doubt due to greater weathering, the upper surface of the leaf is much more readily wettable than the lower, a fact which is easily demonstrated by spraying with water. Moreover, on spraying both surfaces with dilute methylene blue the dye enters the hairs on the upper surface fairly readily, but hardly penetrates those on the lower surface at all. The possibility thus arises that some spray materials may enter the leaf *via* the hairs on the upper side. The hairs on the lower side are wettable with difficulty, so that when the leaf is subjected to a fine mist-like spray of water or lime-sulphur, the liquid adheres in small droplets to the hairs. These hairs do not prevent some spray reaching the actual leaf surface, since numerous small droplets can be seen adhering beneath the mat of hairs. They do not, however, coalesce to form larger wet patches as occurs on the upper surface.

The Effect of Nutrition.

It is a matter of common experience that trees suffering from any form of nutritional disorder are more susceptible to spray damage than completely healthy trees. Wallace (25) has noted that healthy trees suffer less damage from lime-sulphur than weak ones and supposes the cause may be either physiological or due to the more severe attacks of pests on weak trees. Precise data on the causes of such susceptibility are lacking, but it seems that deficiency of particular mineral elements enhances the damaging effect of certain sprays. There is some indication for example (26) that magnesium deficiency increases susceptibility to lime sulphur injury.

Lee and Priestley (13) observed that the thickness of the cuticle on the leaves of various fruit plants was correlated with the relative proportions of potash and calcium in the manurial treatment, low potash being associated with a thin cuticle and low calcium with a thicker one.

Another factor is possibly operative where defective nutrition obtains, namely the alteration which occurs in the physical condition of protoplasm in the presence of excess or deficiency of individual ions in the cell sap or surrounding medium. It has long been known that the sodium ion for instance is toxic when applied to growing tissue as a single salt, but that its toxicity is reduced by the presence of calcium. Similar antagonism occurs between other cations and has been observed to a smaller extent between anions. It is this relationship between different ions, whereby the absorption of one is influenced by the presence of others, that forms the basis of "physiological balance" in culture solutions, and a similar balance is necessary in the soil solution if optimum conditions for growth are to be maintained.

Osterhout (19) has shown that physiologically balanced solutions preserve the normal permeability of the cell, whereas single salt solutions generally increase it. It is thus apparent that the leaf cells of trees receiving badly balanced manurial treatments may be much more susceptible to the loss of solutes from within and the penetration of toxic materials from without than normal healthy leaves. Lime-sulphur for instance applied to trees receiving a deficient or badly balanced manurial treatment often causes a severe loss of foliage, whereas the same wash may be applied with impunity to similar trees whose nutrition is adequate with respect to all the nutrient elements.

It need hardly be said that a "balanced" manurial treatment cannot be specified, since varietal and soil factors modify enormously the manurial requirements in different localities, but if the manurial treatment is such as to produce adequate healthy growth and good cropping it is certain that damage from spray materials will be less than on trees in poor condition due to faulty cultural methods.

An interesting case of damage by lime-sulphur has been brought to the writer's notice by Mr. K. V. Cramp, of Cambridge. Apple trees of the variety Lord Derby on crab stocks, of the same age and growing in the same plantation were sprayed with lime-sulphur at 1 in 80, plus lead arsenate at $2\frac{1}{2}$ lbs. per 100 gallons. No damage occurred on bush trees on 18 inch stems, but the ones on longer stems, $3\frac{1}{2}$ —4 feet, suffered severe scorch. This may perhaps be regarded as a special case of a nutritional effect.

The Effect of Weather Conditions.

It is a matter of general experience that the intensity of lime-sulphur injury depends, other things being equal, on the weather conditions prevailing at the time of application, bright sunlight in particular occasioning a high degree of injury. It is also possible that conditions preceding the application, so far as they affect the anatomy and physiological condition of the foliage, may play a part, accounting for variable injury in different seasons. Esbjerg (7) reported that lime-sulphur injury was greater in years when the first summer months were cold and wet, whilst Dullum (6) obtained injury with similar weather at the actual time of spraying. Conditions following spraying certainly determine the rate of drying of the spray and the degree of retention of spray deposit, whilst frost is a well known cause of damage following lime-sulphur spray on apples and black currants.

EXPERIMENTAL.

1. The Effect of Spraying at Different Times of Day.

In order to obtain some evidence regarding the influence of meteorological conditions at the time of spray application, it was decided to spray a number of trees at different times during the day to see whether the degree of injury could be correlated with temperature, humidity, etc. A uniform block of sixty five-year-old Cox's Orange Pippins on M II stocks was chosen and divided into ten groups of six trees each. Five of these groups were sprayed and the remainder used for a later investigation. Successive groups were sprayed with 2% lime-sulphur at 7.30 a.m., 10.15 a.m., 2.15 p.m., 5.30 p.m., and 10 p.m., respectively on Monday, June 13th, 1938, the trees then being in full leaf. At each spraying, notes were taken of the shade temperature, relative humidity and general weather conditions, and on subsequent days the condition of the foliage was noted and the number of fallen leaves counted for each treatment. It was not practicable to express the leaf fall as a percentage, but since the trees were approximately of uniform size, the figures may be taken as sufficiently representative of this type of injury.

The data are given in Table I and Fig. I from which it appears that leaf fall is correlated with temperature, humidity and sunshine, maximum leaf fall occurring in the afternoon when temperature was high, humidity low and sunshine continuous. No scorch appeared on any of the trees. The weather throughout this week

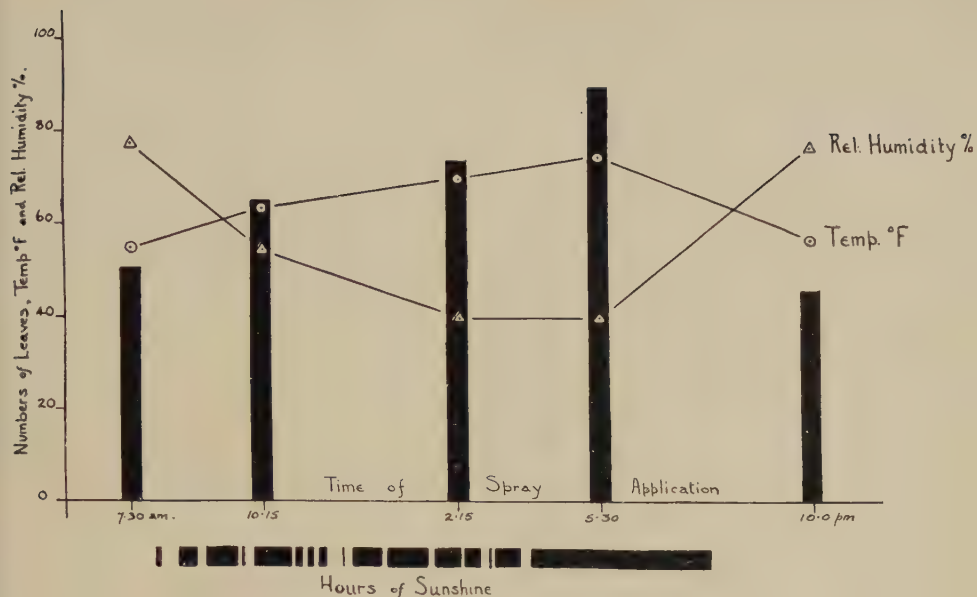


FIG. I.

Effect of Spraying Cox's Orange Pippin at different times of day. Histograms show total numbers of leaves fallen 5 days after spraying with 2% lime-sulphur.

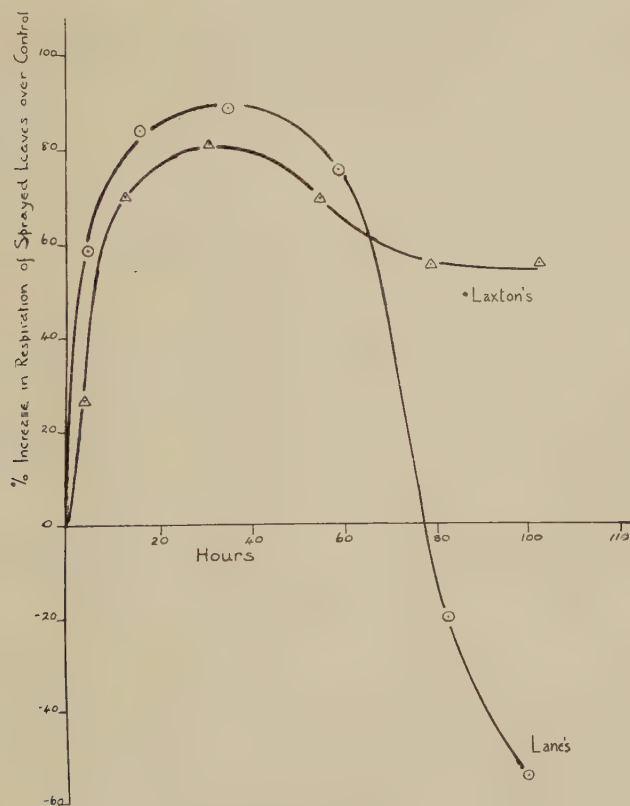


FIG. II.

Effect of 2% lime-sulphur on respiration of detached leaves of Lane's Prince Albert and Laxton's Superb Apples.

was bright, calm and sunny, and the results seem to confirm the experience of growers that injury is more common in bright sunlight than in cloudy conditions. The total hours of sunshine during the week in question were as follows: June 13th (spraying) 9.0, 14th 13.8, 15th 9.1, 16th 14.2, 17th 14.7, 18th 0, 19th 10.3.

TABLE I.
LEAVES SHED BY COX'S ORANGE PIPPIN SPRAYED WITH 2% LIME-SULPHUR AT
DIFFERENT TIMES OF DAY.

Time*	Temp. °F.	Rel. Humidity.	Weather Conditions.	Numbers of Leaves Fallen per Tree on				Total per Tree.
				Tuesday 14th.	Wednesday 15th.	Thursday 16th.	Saturday 18th.	
7.30 a.m.	55°	78	Dry, still and slightly overcast. Sun shining through morning clouds.	10.0	14.0	4.8	21.5	50.3
10.15 a.m.	63.5°	55	Dry; slight breeze. Sun just out.	13.2	23.2	6.3	22.3	65.0
2.15 p.m.	70°	40	Dry, still; warm sun; slightly hazy.	24.3	22.5	7.0	20.2	74.0
5.30 p.m.	75°	40	Dry. Very slight breeze; warm sun; slightly hazy.	13.8	31.0	11.0	34.3	90.1
10 p.m.	57°	77	Dry; still; twilight. Warm, rather close evening.	10.8	10.0	4.0	21.3	46.1

* British Summer Time.

There is some indication that temperature is more important than humidity, for at 2.30 p.m. and 5.30 p.m., the humidity was the same, whereas more leaf fall occurred at 5.30 p.m., when the temperature was higher. A long period of continuous sunshine also occurred at this time. The water content of the leaves would presumably be minimal at this point and the possibility arises that leaf fall may be caused by a desiccating effect of the spray which would be most injurious when the water content was already low. At the same time toxic substances penetrating the leaf would also exert a greater effect due to their greater concentration in the cells.

It is perhaps significant that minimum leaf fall occurred at 10 p.m., when it may be assumed that the stomata were closed, though there is some evidence that the stomata of apple leaves may close much earlier than this (20). Thurston and Miller (23) on the other hand found more injury from lime-sulphur containing arsenic when applied at night than when applied by day.

The trees were examined finally on Friday, June 24th, 11 days after spraying, strong winds and rain having occurred in the meantime. The trees sprayed at 7.30 a.m., and 10.15 a.m., still showed no scorching of the foliage, and the leaf fall after June 18th was very slight. The trees sprayed at 2.15 p.m., showed slight scorching and further appreciable loss of leaves, whilst those sprayed at 5.30 p.m., had rather more scorch and a slightly greater loss of leaf. Scorch was very slight, however, and occurred on occasional leaves only. The trees sprayed at 10 p.m., showed slight scorch and there was some loss of leaves, but much less than for the 2.15 and 5.30 groups. Scorch evidently did not become apparent until 7 to 10 days after spraying.

2. The Desiccating Effect of Sprays.

Accepting as a fact the permeability of the cuticle to water, the application of soluble spray materials provides the possibility of water exchange between the spray fluid and the epidermal cells, and as the spray fluid evaporates from the leaf surface a rapidly increasing osmotic pressure will be set up tending to withdraw water from the leaf cells through the cuticle. Some loss may also occur by the same mechanism through perforations in the cuticle. Whether the passage of water occurs as liquid or as water vapour, the process will be relatively slow, but the possibility remains that in some circumstances, particularly when transpiration is already high, the spray deposit may exert a desiccating action sufficiently strong to result in injury to the leaf.

In order to test this possibility in the field it was decided to spray some trees with relatively inert solutions of high osmotic pressure, and to compare the degree of damage with that occurring on similar trees sprayed with sulphur preparations. It would thus be possible to distinguish roughly between damage due to desiccation alone, and that due to a specifically toxic effect of the sulphur compounds. The solutions chosen as desiccating sprays were 0.5 M sucrose and 0.5 M calcium chloride solutions. 2% lime-sulphur and a preparation of "wettable sulphur" at 5 ozs. per 100 gallons were used for comparison. Blocks of 6 trees each of Cox's Orange Pippin and Lane's Prince Albert were sprayed with the various solutions on Monday, June 13th, between 3 p.m. and 5 p.m., and the subsequent condition of the foliage observed on succeeding days.

The results are recorded in Table II from which it is clear that with both varieties the loss of leaf was much greater from the lime-sulphur sprayed trees than from those sprayed with the desiccating

solutions. The sucrose and calcium chloride solutions caused no more leaf fall from the Cox's than occurred on the unsprayed controls. Unfortunately no trees of Lane's were available as controls, but it seems that these sprays have a much greater effect on this variety than on the Cox's, suggesting that the susceptibility of this variety to damage may be not entirely restricted to sulphur sensitivity.

TABLE II.
EFFECT OF DESICCATING AND FUNGICIDAL SPRAYS ON COX'S ORANGE
PIPPIN AND LANE'S PRINCE ALBERT.

Variety.	Spray Used.	Leaves Fallen per Tree on				Total per Tree.
		Tuesday 14th.	Wednesday 15th.	Thursday 16th.	Saturday 18th.	
Cox's Orange Pippin.	0.5M Sucrose	5.7	10.5	1.0	0	17.2
	0.5M Ca Cl ₂	6.5	12.7	2.8	0	17.2
	Wettable Sulphur.	5.2	All leaves very badly scorched.			
	2% Lime Sulphur.	24.3	22.5	7.0	20.2	74.0
	Control unsprayed.	4.3	7.0	2.0	5.0	18.0
Lane's Prince Albert.	0.5M Sucrose	40.8	27.5	4.5	17.5	90.3
	0.5M Ca Cl ₂	36.7	31.3	5.6	20.0	93.6
	2% Lime Sulphur.	47.5	32.0	6.5	100.0	186.0

Two or three days after spraying, the deposits of sucrose and calcium chloride solutions on the leaves had become so concentrated by evaporation that the leaves were quite sticky. Their potential osmotic effect must have been very great and it is concluded that the rate of removal of water by osmosis was negligible compared to the rate of supply, or alternatively that such loss, if considerable, was not a major cause of leaf scorch or abscission. Since the initial osmotic concentration of the lime-sulphur spray must have been very low in comparison to the sucrose and calcium chloride solutions, it is concluded that the damaging effect of the former is mainly due to a specific effect of sulphur compounds on the leaf and that desiccation plays a relatively minor role.

All the leaves which fell came mainly from the bases of current shoots and from spurs. No young leaves fell from the tips of shoots. On the Lane's trees, scorch was entirely absent and many of the fallen leaves appeared quite healthy. The prevalence of

"Cox Spot" on the Cox's and some damage by aphides made it more difficult to assess the amount of scorch on this variety, but in general it seemed to be negligible except on the trees sprayed with the "wettable sulphur" preparation. These suffered a rapid and severe scorch on all the leaves, so that a day or two after spraying the foliage was completely brown and dry. It seems unlikely, though possible, that this unlooked for effect could be due to the colloidal sulphur alone, and it can only be ascribed to whatever wetting agent was incorporated.

On Friday, June 24th, the trees were examined again. The sucrose had had no further effects on the leaves of the Cox's. The calcium chloride had produced very slight scorch on the Lane's, but not on the Cox's and there was no additional loss of leaf. The Lane's sprayed with lime-sulphur had suffered further considerable defoliation, but this was negligible on the Cox's. The trees were finally examined towards the end of the season when it appeared that no further damage had resulted. The sugar and calcium chloride solutions appeared to have had no lasting detrimental effect.

3. The Effect of Lime-Sulphur on Respiration.

It appeared obvious from the foregoing experiments that lime-sulphur injury was due mainly to some general physiological effect on the foliage rather than to purely physical dehydration or the chemical scorching of the leaves. Accordingly it was decided to investigate the effect of the spray on the behaviour of detached leaves in the laboratory, and since it seems probable that any direct effect of the spray on the leaf cells would be reflected eventually in the rate of respiration it was decided to use respiratory rate as an index of changes in the physiological or metabolic condition of the leaves.

At this time, September 12th, the season was far advanced and growth had practically ceased on the trees available for experiment. It was difficult therefore to obtain ideal material for the purpose, but leaves as similar as possible were chosen from near the tips of terminal shoots of Lane's Prince Albert apples on M II stocks. Fifty leaves were thoroughly mixed, divided into two batches of 25, and the fresh weights of each batch determined. Each leaf of one batch was then lightly sprayed on both sides with a fine spray of 2% lime-sulphur, a smear of vaseline being made round the petioles at the junction with the laminae to prevent spray fluid running down and entering the cut end of the petiole. Each batch of leaves was then placed in a wide mouthed glass jar of four

litres capacity, the petioles standing in small vials of distilled water, surplus spray having been drained from the sprayed batch. The jars were then closed with large cork bungs furnished with inlet and outlet tubes, sealed with "pliocene," and enclosed in black paper.

Air from a gas cylinder was passed separately through each of the jars, having first passed through flow meters, and wash bottles containing respectively 20% sulphuric acid, 20% caustic soda and distilled water. The air stream, adjusted to flow at 10 litres an hour through each line of vessels passed finally through Reiset towers containing 0.2 M potassium hydroxide solution in which the carbon dioxide produced by the respiration of the leaves was absorbed. Two wash bottles containing respectively a slightly acid solution of cadmium sulphate and 0.05 N potassium permanganate solution were inserted between the vessel containing the sprayed leaves and the corresponding Reiset tower to absorb any hydrogen sulphide or oxides of sulphur which would otherwise have been absorbed in the alkali.

The leaves were collected at 11 a.m. on September 12th, sprayed at 12 noon and the air stream started at 12.30 p.m. The alkali in the towers was changed 8 hours after the start of the experiment and subsequently at intervals of approximately 24 hours. The absorbed carbon dioxide was determined by titrating an aliquot of the alkali solution with 0.05 N hydrochloric acid using phenolphthalein and brom-phenol blue, the latter end point being determined by comparison with a buffer solution of half neutralised decinormal formic acid to which a standard amount of indicator was added.

The experiment was repeated on September 19th using batches of 30 leaves of Laxton's Superb from trees of similar age on M II stocks. This variety is normally resistant to sulphur injury compared with Lane's. Leaves were collected at 2.30 p.m., sprayed as before at 3.0 p.m., and the air flow started at 3.30 p.m.

The results obtained are given in Tables III and IV. It is evident that the respiration of the sprayed leaves was considerably in excess of that of the controls both for Lane's and Laxton's. The percentage increase of the sprayed leaves over the controls is plotted in Fig. 2, from which it appears that the increased carbon dioxide production occurred very soon after spraying and attained a maximum about 35 hours later, with both varieties. This increase is not due to the mechanical effect of spraying, because a similar increase was obtained with lime-sulphur when the controls were sprayed with water. There is evidently a specific effect of lime-

sulphur on the respiration rate whereby it is increased beyond the normal starvation curve exhibited by the controls.

TABLE III.
RESPIRATION OF LEAVES OF LANE'S PRINCE ALBERT
SPRAYED WITH 2% LIME SULPHUR.

Period.	Hours.	Total Mgms. CO ₂		Mgms. CO ₂ per gm. Initial Weight per hour.		% Increase Sprayed/ Control.
		Sprayed.	Control.	Sprayed.	Control.	
1	8.00	476.3	283.8	2.565	1.613	59.02
2	14.00	640.2	329.5	1.971	1.070	84.20
3	24.00	750.2	375.1	1.348	0.710	89.74
4	24.00	484.0	259.6	0.869	0.492	76.78
5	24.00	185.9	221.1	0.334	0.419	-20.27
6	18.50	102.3	137.5	0.206	0.463	-55.47

Initial Fresh Weight of 25 Leaves: Sprayed = 23.2 gms.

" " " " Control = 22.0 gms.

TABLE IV.
RESPIRATION OF LEAVES OF LAXTON'S SUPERB
SPRAYED WITH 2% LIME SULPHUR.

Period.	Hours.	Total Mgms. CO ₂		Mgms. CO ₂ per gm. Initial Weight per hour.		% Increase Sprayed/ Control.
		Sprayed.	Control.	Sprayed.	Control.	
1	6.00	137.5	113.3	1.340	1.060	26.41
2	12.00	220.0	152.9	1.072	0.716	70.23
3	24.00	378.4	216.7	0.922	0.507	81.74
4	24.00	239.8	146.3	0.584	0.343	70.53
5	24.00	254.1	168.9	0.619	0.396	56.54
6	24.00	182.6	121.0	0.445	0.283	57.09

Initial Fresh Weight of 30 Leaves: Sprayed = 17.10 gms.

" " " " Control = 17.80 gms.

After about 35 hours the respiration of the sprayed Lane's began to fall more rapidly than the controls, until after 80 hours it had fallen below the latter. This rapid reduction may be explained by the death of many of the cells. Until Thursday, *i.e.* the fourth respiration period, both sprayed and control leaves appeared normal, but on this day there appeared occasional brown areas on the sprayed leaves, corresponding in time with the beginning of the more rapid reduction in respiration. The brown patches in

creased in size and number on subsequent days until the end of the experiment when it became clear that all the sprayed leaves were affected. Their general appearance resembled that of leaves suffering from lime-sulphur injury in the field. They were all quite turgid but had necrotic patches in most cases spreading from the larger branch veins. Curling of the leaf margins characteristic of sulphur injury was also apparent. The unsprayed leaves appeared quite normal and healthy, only differing from their original appearance in that they were more turgid than when first placed in the jar. The sprayed leaves had increased in fresh weight from 23.2 grms. to 29.3 grms., and the controls from 22.0 grms. to 27.2 grms.

The behaviour of the Laxton's was in general similar to that of the Lane's, differing only in degree. The increase in respiration was similar but not quite so marked, but after reaching a maximum in approximately the same interval as the Lane's, declined much more slowly, the rate of carbon dioxide production remaining considerably greater than that of the controls after 100 hours, when the experiment was discontinued. Examination of the leaves then showed that the degree of obvious injury was much less than on the Lane's, necrosis being confined to occasional brown spots which first made their appearance in the fourth period following spraying. These spots were similar to those on the Lane's but much smaller in size and fewer in number, the leaves in comparison being relatively undamaged. The unsprayed controls were perfectly healthy and turgid.

The difference in behaviour of the Laxton's and Lane's is not regarded as entirely varietal, and little importance can be attached to it at this stage since the leaves were not strictly comparable and the experiments were done on different dates. It seems probable that the more rapid fall in respiration of the Lane's is due to the larger number of dead cells. It is unlikely, however, that the initial increase in carbon dioxide production following spraying was due to moribund cells, since the sprayed Laxton leaves maintained a higher rate of respiration than the controls throughout, although a number of the cells were quite dead some time before the end of the experiment. Moreover, the increase seems to have occurred almost immediately after spraying, suggesting a general effect on the leaf as a whole, for no visible signs of injury appeared until 50 to 60 hours after spraying.

When trees are sprayed with lime-sulphur in the field, necrotic patches occur on the leaves where the spray fluid has collected and remained in liquid form longer than on the remainder of the leaf

surface. It thus seems probable that this type of injury is due to direct entrance of spray fluid into the leaf cells either through the intact cuticle or through lesions caused by weathering or by fungus or insect attacks. The scorch caused in the experiment just described was of this type, and since the atmosphere in the vessels containing the leaves was practically saturated with water, the spray fluid was slow in evaporating and no doubt had a longer period in which to penetrate in liquid form than is normally the case in the field.

DISCUSSION.

The incidence and severity of spray injury are closely bound up with the complex set of factors which normally condition the growth of the plant, and whatever the nature of a particular spray material may be, its effects will be largely determined by considerations of soil, climate and the variety of cultural operations which may be in force. It follows that the susceptibility of a particular plant to injury is not constant but may differ at different times of the day or season. Certain varieties, however, are always more or less susceptible, their peculiar morphology or physiological condition rendering them always sensitive to particular spray fluids.

Reference has already been made to the possibility of spray deposit increasing the rate of water loss from the leaf and it was concluded that in the experiments reported, this was a relatively unimportant factor in the production of spray injury. Much work has been done, particularly by Wilson and Runnels (27), on the effects of other sprays on transpiration. These authors showed that Bordeaux mixture in particular brings about a considerable increase in water loss from a wide variety of plants. Duggar and Cooley (5), however, working on tomato plants showed that lime-sulphur (1 in 25) increased transpiration only slightly compared with Bordeaux. It appears from the data of Wilson and Runnels that the large increases observed were due mainly to increased cuticular transpiration, and it seems therefore that loss of water by this means may be an important factor when certain sprays are used, though it appears of little account in the case of lime-sulphur.

Tilemans, in a brief report to Section 8 of the XIIth International Horticultural Congress 1938, has suggested that sensitivity to spray injury is related to the suction pressure of the leaf cells. His conclusion is hardly justified however by his observations that the leaves of Haricot bean have a lower *osmotic* pressure in the sap and are more sensitive to sulphur and arsenical dusts than those of geranium.

Zimmerman and Crocker (29) have shown that wilted plants are more resistant to sulphur dioxide than turgid ones, and McCallan, Hartzell and Wilcoxon (17) in a related investigation found that wilted buckwheat and tomato plants were uninjured by hydrogen sulphide, whilst turgid plants suffered appreciably. Stomatal opening, turgidity and water supply are doubtless all involved in these phenomena, as also in the diurnal variation in injury observed here, but further work is necessary before their precise function in this respect can be assessed.

Mention should be made here of the work of Heinicke (9) and Hoffman (10) on the influence of lime-sulphur on assimilation. These authors measured the apparent photosynthetic rate of apple leaves, the former using a complete ten year old tree and the latter single leaves. In both cases a marked reduction of assimilation of the sprayed leaves occurred. No particular attention was paid to respiration, but Hoffman noted that in one case when visible injury occurred on the leaves, respiration increased beyond the rate of photosynthesis. There is no evidence to show whether respiration was affected in other cases, but since the carbon dioxide measured was always the resultant of respiration and assimilation it is possible that respiration may have been increased without exceeding the amount of carbon dioxide absorbed in photosynthesis. Heinicke measured respiration during the night periods and states that it was unaffected by spraying. Since the experiments described here were conducted with leaves in the dark, photosynthesis was not involved.

Hoffman regards the effect of lime-sulphur as probably due to a chemical interference with the photosynthetic mechanism, but it seems difficult to conceive such an interference affecting photosynthesis without simultaneously affecting respiration. Sanders (22) states that lime sulphur enters the leaf *via* the stomata and causes degeneration of the chlorophyll, but this can hardly be the case when no visible injury becomes apparent.

The fungicidal activity of sulphur has been variously attributed by different workers to soluble sulphides, pentathionic acid, sulphur vapour, hydrogen sulphide and sulphur dioxide. There is much evidence that sulphur can exert its fungicidal activity at a distance, and it seems certain that a volatile or gaseous product is involved. Goodwin and Martin (8) have investigated chemically the volatile products of sulphur under various conditions when not in contact with living tissue, and have concluded that the toxic agent is either hydrogen sulphide or volatile sulphur. Barker (3), Marsh (15), and later McCallan and Wilcoxon (16) have all shown that sulphur in contact with the green leaves of a large variety of plants as well

as numerous species of fungi is reduced to hydrogen sulphide, and it seems certain that the reduction involves the activity of an enzyme containing the sulphydryl group, which is probably identical with glutathione. McCallan and Wilcoxon attribute the fungicidal activity of sulphur to the production of sulphur vapour which diffuses into the fungal spores where it is reduced to hydrogen sulphide, the latter being the effective toxic agent, a conclusion arrived at by Barker in 1927 (2). They state that it is unlikely that hydrogen sulphide produced by the reaction between the leaves and sulphur dust affects the spores, but so far as injury to the foliage is concerned it seems very probable that hydrogen sulphide produced in this way might have a direct effect on the leaf protoplasm.

McCallan, Hartzell & Wilcoxon (17) have recently studied the nature of hydrogen sulphide injury to a large number of plant species including apple, and have drawn attention to the close similarity between this and lime-sulphur injury.

As early as 1914, however, Salmon (21) recognised that some volatile substance might be responsible for lime-sulphur injury. In investigating the action of various sulphur sprays on American Gooseberry Mildew in the field, he observed that some days after spraying a plantation of May Duke gooseberries with lime-sulphur, many bushes of some adjacent rows of the very sensitive variety Yellow Rough had shed their leaves although no spray had actually touched them. He says "It seemed clear that in this case the gas (either sulphuretted hydrogen or sulphur dioxide) which is given off from the lime-sulphur wash when exposed to the air, was responsible for this leaf fall. To determine this point, some lime-sulphur was sprayed over the soil surrounding some bushes of Yellow Rough, care being taken that none of the spray touched the bushes. After a few days considerable leaf fall resulted." Salmon was not aware of the reduction of sulphur to hydrogen sulphide by contact with leaves, but in the case of lime-sulphur, hydrogen sulphide is produced without this reaction. Atmospheric carbon dioxide gradually decomposes lime-sulphur with the formation of elementary sulphur, hydrogen sulphide and calcium carbonate, and it seems clear that when spray fluid is deposited in intimate contact with leaves, this decomposition may be greatly accelerated by the carbon dioxide produced during respiration. Where lime-sulphur is used, therefore, hydrogen sulphide is undoubtedly evolved independently of the reduction of elementary sulphur, though the latter may also occur.

In this connection it is significant that Wallace (25) found less injury to be produced on apples and peaches by lime-sulphur which

was first treated with carbon dioxide. He believed this to be due to the precipitation of soluble sulphides which he regarded as the cause of injury, but it is equally likely, that the reduced toxicity was due to the evolution of hydrogen sulphide and its consequent removal before the spray came in contact with the foliage. It is not clear, however, whether the injury referred to by Wallace is of the kind resulting in shedding of leaves, which the evidence suggests may be due to hydrogen sulphide, or burning of the foliage, which is most probably due to direct penetration of spray fluid.

Further evidence is provided by analogy with the work of Miller (18, 18a). He has shown that hydrogen sulphide, in common with several other sulphur compounds, is effective in breaking the dormancy of potato tubers and also brings about an immediate and remarkable increase in the rate of respiration. Respiration attained a maximum 50 to 60 hours after treatment and then declined to normal after about a week. This increase bears a significant resemblance to the effect upon respiration obtained here with apple leaves sprayed with lime-sulphur and lends support to the view that hydrogen sulphide may also have been responsible for this latter effect.

Miller has also shown that the effect of hydrogen sulphide is not only to increase the rate of carbon dioxide production, but that the enzyme activity and sucrose content of potato tissue are also increased. In view of the evidence presented it seems not unlikely that a similar sequence of events may also occur in sprayed apple leaves. The foliage leaf, consisting mainly of thin walled mesophyll cells in intimate association with the highly ramified vascular and aeration systems is particularly adapted to the rapid exchange of gases with the external atmosphere and their distribution throughout the tissue of the leaf, and the presence of a toxic gas, particularly a water soluble one like hydrogen sulphide, produced in close contact with the leaf, would rapidly result in the kind of effect on respiration observed in these experiments.

Further work is necessary to establish the possible effect of lime-sulphur on the enzyme activity and sugar content of the leaf, but it is suggested as a hypothesis that the hydrogen sulphide evolved from spray fluid deposited on the leaves acts upon the leaf protoplasm in such a way that enzyme activity is increased and conditions arise similar to those existing at normal leaf fall, giving rise to abscission of the leaves on sulphur sensitive varieties. These conditions need to be further investigated, and it still remains to be explained why some varieties are more susceptible to this type of injury than others. This will form the subject of investigations in the coming season.

SUMMARY.

1. Symptoms of lime-sulphur injury are described and a list presented showing the relative susceptibilities of some varieties of common fruit plants to sulphur injury.

2. The penetration of spray materials into the leaf is discussed with particular reference to cuticle permeability, and the effect of nutritional and climatic factors.

3. An experiment is described which suggests that foliage injury from lime-sulphur may be correlated with temperature, humidity and sunshine. Maximum injury occurred when temperature was high, humidity low and sunshine continuous.

4. The possibility that desiccation by spray deposit may be a major cause of injury was investigated. Concentrated sprays of sucrose and calcium chloride produced little damage compared with lime sulphur. It is concluded that loss of water due to the purely osmotic effect of spray deposit is not alone responsible for spray injury.

5. Detached leaves of Lane's Prince Albert and Laxton's Superb apples exhibit rapid increases in respiration when sprayed with 2% lime-sulphur and show symptoms of injury similar to those observed in the field. Necrotic patches are believed to result from local penetration of spray fluid, but the increase in respiration seems due to a more general physiological effect on the whole leaf.

6. Possible causes of the observed effects are discussed and it is suggested that injury from lime-sulphur of the type resulting in leaf abscission is due to a gaseous or volatile compound, which the evidence suggests may be hydrogen sulphide.

Acknowledgment.

Thanks are due to Dr. H. Martin for his advice and interest in this work.

REFERENCES.

- (1) ARENS, K. Die Kutikuläre Exkretion des Laubblattes. *Jahrb. f. wiss. Bot.* 80, 248, 1934.
- (2) BARKER, B. T. P. Investigations on the Fungicidal Action of Sulphur. (Progress Report). *Ann. Rep. Res. Long Ashton*, p. 72, 1927.
- (3) BARKER, B. T. P. Investigations on the Fungicidal Action of Sulphur IV. Third Progress Report. *Ibid.* p. 130, 1929.

- (4) DAXER, H. Untersuchungen über den Ersatz arsenhaltiger Bekämpfungsmittel. IV. Die Einwirkung von Giftstoffen auf die Pflanze. I. Grundlegende physiologische Fragen und Versuche zur Klärung der Arsenwirkung. *Zeitschr. Pflanzenkrankh.*, 48, 273, 1938.
- (5) DUGGAR, B. M. and COOLEY, J. S. The Effect of Surface Films and Dusts on the Rate of Transpiration. *Ann. Mo. Bot. Gard.*, 1914. I. 1-23, cited from *Miller's Plant Physiology*, 1938.
- (6) DULLUM, N. Experiments using a Combination of Lime-Sulphur and Bordeaux Mixture on Apple Trees. *Bordeauxvaedskes Projtninger Til Aebtletraefr Tidsskrift f. Planteavl*, 37, 641, 1931.
- (7) ESBJERG, N. Experiments on the Profitableness of Spraying Apple Trees. *Ibid.*, 35, 517, 1929.
- (8) GOODWIN, W. and MARTIN, H. The Action of Sulphur as a Fungicide and as an Acaricide. *Ann. Appl. Biol.* 15, 623, 1928.
- (9) HEINICKE, A. J. How Lime-sulphur Spray Affects the Photosynthesis of an entire ten year-old Apple Tree. *Proc. Am. Soc. Hort. Sci.*, 35, 256, 1937.
- (10) HOFFMANN, M. B. The Effect of Certain Spray Materials on the Carbon Dioxide Assimilation by McIntosh Apple Leaves. *Ibid.*, 29, 389, 1932.
- (11) JAMALAINEN, E. A. Prufung der Pflanzenschutzmittel in Dänemark und Deutschland. *Staatliche Landwirtsch. Versuchstätigkeit*, No. 97, 1938.
- (12) KAMP, H. Untersuchugen über Kutikularbau und Kutikuläre Transpiration von Blättern. *Jahrb. wiss. Bot.*, 72, 403, 1930.
- (13) LEE, BEATRICE and PRIESTLEY, J. H. The Plant Cuticle. I. Its Structure Distribution and Function. *Ann. of Bot.*, 38, 525, 1924.
- (14) MANN, C. E. T. and WALLACE, T. The Effects of Leaching with Cold Water on the Foliage of the Apple. *J. Pom. and Hort. Sci.*, 4, I, 237, 1925.
- (15) MARSH, R. W. III. Investigations on the Fungicidal Action of Sulphur. Studies on the Toxicity of Sulphuretted Hydrogen and on the Interaction of Sulphur with Fungi. *J. Pom. and Hort. Sci.*, 7, 237, 1929.
- (16) MCCALLAN, S. E. A. and WILCOXON, F. The Fungicidal Action of Sulphur. II. The Production of Hydrogen Sulphide by Sulphured Leaves and Spores, and its Toxicity to Spores. *Contrib. Boyce Thompson Inst.*, 3, 13, 1931.
- (17) MCCALLAN, S. E. A., HARTZELL, A. and WILCOXON, F. Hydrogen Sulphide Injury to Plants. *Ibid.*, 8, 189, 1936.
- (18) MILLER, L. P. Effect of Sulphur Compounds in Breaking the Dormancy of Potato Tubers and in Inducing Changes in the Enzyme Activities of the Treated Tubers. *Contrib. Boyce Thompson Inst.*, 5, 29, 1933.
- (18a) MILLER, L. P. Effect of Various Chemicals on the Sugar Content, respiratory rate and dormancy of Potato Tubers. *Ibid.*, 5, 213, 1933.
- (19) OSTERHOUT, W. J. V. Antagonism and Permeability. *Science N.S.*, 45, 97, 1917.
- (20) PICKETT, W. F. The Relationship between the Internal Structure and Photosynthetic Behaviour of Apple Leaves. *Kansas Agric. Expt. Sta. Bull.*, 42, 1937.
- (21) SALMON, E. S. American Gooseberry Mildew. *Journ. Ministry of Agriculture*, 20, 1057, 1914.

- (22) SANDERS, G. E. *Ann. Rep. Nova Scotia Fruit Growers Assoc.*, 54, 1915.
72, cited from Martin, H., *Scientific Principles of Plant Protection*, London,
1936.
- (23) THURSTON, H. W. and MILLER, J. Experiments with Liquid Lime-sulphur
for Spraying Apples. *Phytopath.*, 28, 823, 1918.
- (24) WALLACE, T. Experiments on the Effects of Leaching with Cold Water on
the Foliage of Fruit Trees. I. The course of leaching of dry matter, ash
and potash from leaves of apple, pear, plum, black currant and gooseberry.
J. Pom. and Hort. Sci., 8, 44, 1930.
- (25) WALLACE, E. Spray Injury induced by Lime-Sulphur Preparations.
Cornell Univ. Agric. Expt. Sta. Bull., 288, 1910.
- (26) WALLACE, T. Magnesium Deficiency of Fruit Trees. (In the Press).
- (27) WILSON, J. D. and RUNNELS, H. A. *Ohio Sta. Bimon. Bull.*, 1931-35, cited
from Miller, E. C., *Plant Physiology*, McGraw Hill Co., New York, 1938.
- (28) YOUNG, H. C. and WALTON, R. C. Spray Injury to Apple. *Phytopath.*, 15,
405, 1935.
- (29) ZIMMERMAN, P. W. and CROCKER, W. Toxicity of Air containing Sulphur
Dioxide Gas. *Contrib. Boyce Thompson Inst.*, 6, 455, 1934.

ACCIDENT PREVENTION IN THE USE OF POISONOUS SPRAY MATERIALS.

By H. MARTIN.

The widespread use of poisons such as lead arsenate and nicotine as horticultural spray materials has naturally aroused fears of mishaps to human beings and stock. Public Health authorities and even the general public may demand enquiry and regulation, especially in countries where the use of such materials has unfortunately to be extensive. The recent spread of Colorado Beetle across France and the neighbouring countries and the consequent increased employment of arsenical stomach poisons; the development, on the Continent, of aeroplane dusting of calcium arsenate for the control of forest-pests; the necessity of applying lead arsenate for the control of Codling Moth in colonial and American apple plantations so late in the growing season that there is a danger of the poison persisting on the picked fruit; such are examples of developments which have made the problem of special urgency abroad, and which led to a discussion of the subject at the XII International Horticultural Congress recently held in Berlin. At this Congress, representatives from the various participating countries were invited to outline the precautions taken, in their respective countries, to safeguard public health and to avoid the accidental poisoning of man and stock. Much interesting information was thereby accumulated not only on these points, but on questions of spray damage to crop-plants and of non-poisonous substitutes. This information will eventually be published in the Proceedings of the Congress, but an opportunity may be taken of comparing the situation abroad with that in this country. In so far as the important question of spray damage is concerned, the discussions yielded little novel information, but served to emphasize the paucity of knowledge on this difficult subject. Much was said, however, of the non-poisonous substitutes, but as these have received much attention in the scientific and popular press it is not proposed to discuss this subject here. The present

article is confined to measures of accident prevention, a topic upon which little has been published. The Pharmacy and Poisons Act, 1933, while framed to facilitate the proper use of poisons, imposes certain restrictions not always well known to growers. In addition there are many precautions not legally enforced, the observation of which will tend to reduce public anxiety and allay a possible prejudice, by the food consumer, against fruit and vegetables subjected to occasional treatment with poisons.

In reviewing these regulations and precautions, the simplest plan is to begin with the purchase of the poison and to proceed, *via* storage and application, to the sale of the produce. At each stage there is a scale of severity, from legislation to recommendation, in the measures adopted, for the term poison is of relative significance. The likelihood that accidents will arise in the use of a particular poison will depend, not only on actual toxicity, but on factors such as the possibility of mistaking the poison for an innocuous material. Lead arsenate for example, in the form of white chalk-like powder is more dangerous than Paris Green, the colour of which assists in its identification as a poison. It is reported that a recent fatal mishap was due to the mistaking of nicotine for cold tea !

Regulations concerning Sale.

Prohibition is the most drastic restriction, but this is possible only when effective, but less dangerous, substitutes exist. Strychnine, for example, was at one time used for vermin control, for which purpose Red Squill is suitable. The Poisons Act now makes it unlawful to obtain or to use strychnine or *Nux Vomica* for any purpose that is not medicinal. Certain bacterial cultures or "viruses" are also used for vermin control, but their use is prohibited in Germany, where it is also a punishable offence to apply lead arsenate to vines. It is there considered that the dangers of cumulative lead poisoning are sufficient to justify the enforcement of the substitution of lead arsenate by calcium arsenates.

Prohibition may also be achieved by indirect means in countries where the sale or manufacture of pest control products is subject to official control. In Canada, for example, the Agricultural Pests' Control Act of 1927 prohibits the manufacture, importation or advertisement of pest control products which are not registered with the responsible Minister, who can refuse to register any product if, in his opinion, it is generally detrimental to vegetation (except weeds), domestic animals or public health. The licensing or

registration of insecticides and fungicides is legally required in many European countries, including Germany, Hungary, Poland and Roumania, a regulation which not only affords protection to the general public from highly dangerous poisons, but which safeguards the grower against ineffective products.

When permitted, the sale of dangerous products may be controlled by regulations affecting either the seller or purchaser or both. Such regulations may differentiate between poison classes, less drastic restriction being placed on products considered less dangerous. In this country, for example, the seller must be registered either as a pharmacist by the Pharmaceutical Society or as a "listed seller" by the local authority. The "listed seller" is permitted to deal only in certain scheduled poisons which must be in a form suitable for use in agriculture and horticulture. Arrangements of a similar character obtain in most European countries, but, in Denmark, an additional restriction is that the authorized seller is not permitted to re-weigh or re-pack certain pest control materials. In all cases, however, the authorized seller is subject to rules, the main purposes of which are to prevent sale to incompetent persons and to facilitate the tracing of poisons after sale by the recording of particulars and, usually, the securing of a signed receipt from the purchaser.

The signing of the "poison book" by the purchaser is almost universally enforced, one exception being in this country where, in cases of emergency, the professional grower may be supplied with poisons scheduled for use in horticulture on the understanding that he will furnish the requisite signed order within twenty-four hours. Additional precautions are adopted elsewhere, as in Norway, where the purchaser is required to sign a declaration that he will not give the material to any incompetent person or, as in Denmark, that he will observe due care in the storage and application of the product. Further, in Denmark, proof of competence is required and special instructional courses are held by the State Phytopathological Service. Since 1929 more than a thousand growers have attended such courses and secured the right to purchase poisons direct from the wholesaler. A similar principle is adopted in Austria where cyanide fumigation can be carried out only by persons who have passed a course of instruction in the method. In Holland, cyanide fumigation by the "pot" method, *i.e.*, using alkali cyanide and acid, is limited to officials of the Plant Protection Service though the use of safer cyanide products is less restricted.

The distinction between qualified and unqualified users is

paralleled, in this country, by the status of professional and amateur. The professional, being engaged in horticulture by way of trade or business, is allowed greater facilities than the amateur, the more important being the right to obtain a wider range of poisons direct from the wholesaler or manufacturer, and the twenty-four hour grace referred to above.

Regulations concerning Packaging.

The main purpose of these regulations is to render the dangerous poison, or package containing it, distinctive and less likely to be mistaken for an innocuous substance. An obvious example is the distinctive colouring of lead arsenate for which purpose a water-soluble dye is required by Statutory Rules and Orders 1936, No. 363 of the Poisons Rules. Similarly, in some Swiss cantons, the addition to arsenicals of a specified dyestuff or malodorous ingredient is enforced.

A distinctive leak-proof container is required in many countries, especially for liquids. In Victoria, for example, nicotine containers must be embossed while, in Great Britain, liquid poisons in amounts of six pints or less must be packed in bottles fluted vertically with ribs or grooves recognizable by touch.

Lastly, the use of distinctive labels may be required. Perhaps the most thorough example of this type of precaution is from Norway where the label must bear, in clear black letters on a red background the name of the product, a "death's head" sign, the prescribed warning ("Care, Poison. Not to be taken. Must be kept under lock and key.") and the poison symptoms. The label must also bear the name of the manufacturer, the content of active constituents and the purpose for which the material is to be used. Further, instructions for use which must have the approval of the Department of Agriculture must be included in the package or on the label. Other safeguards which may be adopted are the statement, on the label, of date of delivery, required in Denmark, and directions for treatment in case of poisoning required, in Victoria, upon nicotine containers.

In other countries less comprehensive labelling may be adopted, the extreme being in some Swiss cantons, where a distinctive trade name is required for poisonous pest control products. Similarly, in Poland, such products are usually given a special trade name

because poisons designated in chemical terms are obtainable only by medicinal prescription.

The labelling requirements in this country are less comprehensive but are complicated by the sub-division of poisons into different classes. Containers of sodium hydroxide (caustic soda), for example, must bear the words "Caution. This substance is caustic," but most other poisons require a label bearing the word "Poison" in red lettering or set against a red background. Bottles of not more than six pints capacity, if containing a liquid poison, must also be labelled with the words, "Not to be taken." Finally, the label of a container of a preparation compounded with an ingredient specified as a poison must include a statement of the content of that ingredient. Purchasers of tar distillate washes, for example, will have noted that the label includes a statement of the content of phenols in the product. This statement is required as phenols are specified in the Poison List but it conveys little information on the virtues of the product as a winter wash. There is little justification for the grower who complained, according to one manufacturer, that the latter's product, stated to contain 8 per cent. phenols W/W, was not as good as that of a competitor because it contained less phenols.

At first sight it might appear that this question of containers and labelling had little direct interest to the grower, but the law is not limited to containers as purchased but applies to all containers. If therefore the grower adopts the practice of keeping bulk supplies of spray materials under lock and key and, if issuing supplies to his men as they are required, the containers in which he issues the materials must conform to regulations. For example, the grower, who for convenience weighs out lead arsenate powder in convenient amounts in thin paper bags which are later handed to his workmen, is committing an offence. Or suppose that a glasshouse grower, hands to his foreman a medicine bottle containing the right amount of nicotine for a particular job and by accident that bottle is mislaid with fatal consequences, the grower would find himself in a most serious position at the inquest. To safeguard himself and his workmen he should have placed the nicotine in a properly labelled and fluted poison bottle.

Precautions during Transport, Storage and Application.

That dangerous poisons should be transported and stored with care is such obvious commonsense that there is little to be said on

this point. But it may not be generally known that the person who carelessly throws a package containing certain pest control products amongst vegetables or other foodstuffs he may be carrying in his cart or lorry, is breaking the law. The Poisons Rules require that, if any arsenical poison, salts of barium or thallium, cyanides, nicotine or strychnine be carried in any vehicle in which food is being transported, adequate protection must be made from risk of contamination.* In matters of storage it would seem that growers observe the commonsense rule that the poisons should be inaccessible to children and incompetent persons for legislative measures are not usually adopted. In S. Africa it is an offence to keep poisons in the same cupboard as foodstuffs, in Austria their storage in living rooms, kitchens and stables is forbidden whilst, in France, arsenicals must be kept under lock and key.

In this country there are no special regulations concerning the application of poisonous spray materials, but from legislative measures adopted in other countries the following hints deserve mention. The preparation of Paris Green-bran baits, for example, is regulated in Egypt where they are widely used for locust control. The mixing must be under the supervision of a senior official who is instructed to comply with the following regulations: to see that the workmen have no open wounds, for the arsenites produce festering sores when applied to broken skin; to instruct the workmen to cut their finger nails, to smear their hands with fat, to wear goggles and to wash thoroughly before taking food. In parts of Switzerland it is legally required that tubs used for the mixing of poisonous sprays must bear a conspicuous inscription of "Poison." Other points are that the residues of spray not applied and the water used to clean and wash out the spray appliances should be emptied into deep earth pits and covered with earth.

A frequent enquiry of growers concerns the danger to stock pastured in sprayed orchards. In some countries the risk is considered to justify legislation, and in Hungary grazing is wholly prohibited in orchards where arsenicals are applied. Similarly under conditions when the application of arsenical dusts to fodder plants is necessary, as in Sweden, cutting for hay or ensilage is not permitted until five weeks after the last application. Experimental evidence indicates, however, that in sprayed orchards there is little danger in stock feeding upon the pasture. Sheep fed without ill effects on grass actually sprayed with Paris Green and, in America, on grass sprayed with lead arsenate at 12 pounds per 100 gallons. In the latter experiments calves exhibited slight poison symptoms, but poultry were unaffected. To be on the safe

side it is better and more convenient to remove stock during the actual spraying, but they may be readmitted as soon as pools of spray, which may collect on the ground, have dried and the spray appliances, containers and mixing tubs have been removed or hurdled off. Possible indirect effects of the spray upon the pasture should, however, be borne in mind. The immediate after-effect of a tar oil spray for example, will be to reduce available grass which, however, regrows to a full flush which may cause scouring unless suitable precautions are taken.

Precautions to be taken concerning time of application are designed either to prevent injury to pollinating insects or to reduce the dangers of spray residues upon the harvested crop. In this country the growers' good sense in avoiding interference with pollination and in protecting bees is sufficient to prevent the application of bee poisons such as arsenicals or derris during blossoming, but this precaution is legally enforced in Hungary, Italy and parts of Germany. In the last country, local police decrees may, at the same time, prohibit the application of copper fungicides. The serious losses of bee-keepers, in districts where the widespread aeroplane application of calcium arsenate dust for the control of pests of forest trees is practised, are receiving official attention in Germany.

The problem of spray residues with the attendant risk that a sufficient amount of poison will remain on the harvested crop to endanger public health, is not acute in this country. Danger may arise in those fruit plantations where vegetable under-crops are taken but most growers are alive to this danger and there are no legislation restrictions. Actually the legal situation is somewhat indefinite. The toleration observed for arsenical residues, for example, is one hundredth of a grain of arsenious oxide per pound or gallon, a quantity based upon the recommendations of the Royal Commission of 1903, appointed to enquire into the causes of an outbreak of arsenical poisoning arising in Lancashire through the presence of arsenic in beer. This recommendation still has no statutory effect but is adhered to by Courts of Law in carrying out regulations under Public Health Acts dealing with food.

Abroad, official regulations have been adopted to minimise the chance of poisonous spray residues on foodstuffs. In Sweden for example, the use of arsenicals is prohibited on fruit trees undercropped with vegetables of which the leaves serve as food. The same object is attained in Hungary by prohibiting the growing,

as undercrops in fruit plantations, of vegetables other than those which are peeled or washed before use. In countries where late spraying is necessary for the control of Codling Moth an indirect restriction is imposed by the limitation of the quantity of poison on the harvested crop to below a legal maximum before such crops can be exported. In the United States, for instance, the tolerances allowed for interstate shipment of fruit are defined and have recently been raised to one-fortieth grain per pound of lead and one-hundredth grain arsenic or fluorine per pound.

Although it is imperative that due care should be taken to prevent ill-effects through the consumption of food containing poisonous spray residue, it seems questionable whether legislation is to the general good of public or grower. In the first place if the possibility is brought to the attention of the consumer it might prejudice him against such foodstuffs. The possibility is so remote that this prejudice is undeserved. A prominent American entomologist has recently assessed the danger of death from spray residues to be in the same class of hazard of being killed by a golf ball or by falling out of bed. In the second place there is the danger that the tolerances will be put to extreme uses with consequent increase in cost of production. An example of this point occurred in general advisory work when a grower insisted upon a copper sulphate free from arsenic. He intended to use the bluestone for the preparation of Bordeaux mixture for application to hops, the last of three sprayings to be just after burr when the hop itself had just formed. His choice of bluestone was between a sample of good commercial quality containing perhaps a grain of arsenious oxide per pound and a sample of the highest purity costing twice as much and within the tolerance of one-hundredth grain arsenious oxide per pound. When it is considered that the bluestone is first diluted to spray strength, is applied well before hop picking so that the hops have grown out and the leaves have lost much of their Bordeaux residue by picking time, there is justification for the view that the additional cost of the high grade bluestone is unwarranted. The grower might have proposed, with like reasonableness, that he tied each hop in a small paper bag to protect it from dust which nearly always contains arsenic in amounts above the tolerance.

For these reasons legislation seems, in this country, to be an unwanted method of safeguarding public health against the dangers of spray residue or, while every care should be taken to avoid the danger, over-emphasis on this point may be as ill-judged as its neglect.

SUMMARY.

The extensive use of pest control materials poisonous or hazardous to human beings has aroused the apprehensions of Public Health authorities especially on the Continent. The grower can do much to prevent accidents and to allay public anxiety. The various methods of accident prevention are reviewed, and the precautions legally enforced or voluntarily observed in different countries are compared. Attention is especially directed to legislative measures affecting growers in this country.

CIDER MAKING TRIALS FOR THE SEASON 1937 - 1938.

By P. T. H. PICKFORD.

In all the Counties the 1937 cider apple crop was lighter than that of the previous year, and was especially poor in Gloucester, Hereford and Worcester.

The average specific gravity of all the juices examined at Long Ashton was 1.054, a satisfactorily high average, showing a big increase on the previous year's value which was only 1.0469.

The general quality of the cider and perry was very variable, the unfavourable climatic conditions at the end of the summer evidently affecting a number of varieties. Most of the sweet varieties and the milder bittersweets were of outstanding, high quality, but the sharp varieties and the full bittersweet types were rather harsh in flavour.

Competitions were arranged on similar lines to those of previous years. No additional variety trials were made, all the single varieties which were procured in addition to the Competition entries being included in the Cider House Experimental Programme.

The Cider Competitions.

For the thirteenth year in succession these competitions constituted an important feature of Cider House work. They were arranged on similar lines to those described in previous reports. The variety classes were divided as in the previous years, and again special prizes were awarded for the best sharp, sweet and bitter-sweet varieties which had not previously obtained prizes in the former competitions.

Special prizes were also awarded for consignments of fruit received in the best condition, an account of which is given elsewhere in this Report (pp. 171-173).

95 entries were received, of which 78 were apples and 17 pears.

The competitions were open to growers residing in the same counties as listed in previous years. The entries from the individual counties were as follows :—Devon, 11 ; Gloucester, 11 ; Hereford, 10 ; Monmouth, 11 ; Somerset, 50 ; Worcester, 2.

The ciders were judged on April 26th and 27th, 1938, by Dr. H. V. Taylor, Ministry of Agriculture and Fisheries, 10, Whitehall Place, London, S.W.1 ; Mr. H. T. Williams (Williams Bros.), Backwell, near Bristol ; and Mr. E. Ball (Messrs. H. P. Bulmer & Co. Ltd.), Hereford. The perries were judged at the same time by Mr. J. W. Pullin (Pullin Bros.), Compton Greenfield, Glos. They reported as follows :—

“ The judging of the ciders and perries in these Competitions took place on April 26th and 27th, 1938.

The quality of the ciders in the different classes varied to a marked degree. The more acid ciders and the full bittersweets were not of a high standard of quality ; the low acid and the low tannin ciders were good, and for these this year could be described as a “ Vintage ” year.

The bittersweet ciders were divided into three sections to facilitate judging, and some difficulty was experienced in deciding on the appropriate classes for some of the ciders.

Class 1 (for Kingston Black) consisted of 7 entries. Only two could be described as typical Kingston Black Cider. The other ciders lacked character and were below the high standard expected for this variety.

Class 2A (for Sharp Varieties). The ten ciders entered were not particularly good. They were of medium standard only and the acid character was harsh.

Class 2B (for Medium Sharp Varieties) was a good class, containing many pleasing ciders, a big proportion of which made pleasant drinks unblended. The cider selected for the first prize was particularly good. There were 14 entries.

Class 3 (for Sweet Varieties), comprising 16 entries of Sweet Ciders, contained the best ciders in this year's competitions. All were good and of fine, even quality. The climatic conditions during the summer and autumn of 1937 evidently favoured the full development of the special Sweet Alford flavour, for the entries of this variety made excellent ciders.

Class 4A (for Mild Bittersweets), 12 entries of good ciders. The considerable variation in the tannin character made the judging extremely difficult, and agreement amongst the judges was not reached easily.

Class 4B, contained some very good Medium "Bittersweet" ciders, the majority of which were valuable for blending. There were 10 entries.

Class 4C (for Full Bittersweets), contained 9 entries, and these were only of fair quality. Although most of the entries were useful for blending they were not full-bodied, and in some cases the astringency was crude and unpleasant.

Class 5 (for Perries) attracted 17 entries. They were on the whole good and showed an improvement on last year's class. The entries of Blakeney Red were all very similar in character and produced pleasant soft-flavoured beverages. They were quite different in character from the other varieties, such as Butt and Oldfield. The entries of Butt were below standard, whilst the Oldfield perries were too pronounced in acidity.

We express our appreciation of the way in which the ciders and perries in the various classes were placed before us. The particularly clean flavour throughout and the absence of taints indicated the care which had been taken during the fermentation and storage processes."

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (a) Time of Filtering. (b) Date of Judging. (April 26/38).	Notes on Ciders.
CLASS 1.—KINGSTON BLACK ONLY.				
No. 1. (Barton St. David, Som.)	1.062 (23/11/37)	M. 0.62 T. 0.17 F. 3.1	(a) 1.030 (23/2/38) (b) 1.030 (26/4/38)	Good quality cider, very clean in flavour and aroma, but rather too acid.
No. 2. (Dunkerton, Bath, Som.)	1.062 (23/11/37)	M. 0.59 T. 0.16 F. 3.7	(a) 1.030 (29/1/38) (b) 1.030 (26/4/38)	Not very full in flavour; lacking character.
No. 3. (Hewish, Som.)	1.073 (23/11/37)	M. 0.73 T. 0.22 F. 4.4	(a) 1.030 (11/3/38) (b) 1.029 (26/4/38)	A very pleasant cider: fuller in flavour with much more character than the previous sample.
No. 4. (Womastow, Mon.)	1.069 (23/11/37)	M. 0.70 T. 0.21 F. 3.8	(a) 1.030 (24/3/38) (b) 1.030 (26/4/38)	A very good cider but the acid flavour was rather too pronounced.
No. 5. (Taunton, Som.)	1.059 (23/11/37)	M. 0.50 T. 0.17 F. 2.0	(a) 1.030 (17/3/38) (b) 1.030 (26/4/38)	A very "soft," fruity-flavoured cider with good character and aroma.
No. 6. (Bushley, Wores.)	1.065 (23/11/37)	M. 0.60 T. 0.17 F. 3.9	(a) 1.030 (17/2/38) (b) 1.036 (26/4/38)	Rather thin in flavour; although pleasant it was rather too acid and lacked body.
No. 7. (Ross, Hereford)	1.069 (23/11/37)	M. 0.82 T. 0.20 F. 4.4	(a) 1.030 (26/2/38) (b) 1.029 (26/4/38)	Very thin and much too acid.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) % Tannin (T) % and Rate of Fermentation (F).	Gravity at Time of Filtering. (a) (b) Date of Judging. (April 26/38).	Notes on Ciders.
SHARP VARIETIES.—				
CLASS 2A.—Varieties of high acidity, suitable only for blending.				
Cap of Liberty. (Burghill, Hereford)	1.053 (19/11/37)	M. 0.79 T. 0.21 F. 3.5	(a) 1.030 (25/1/38) (b) 1.030 (26/4/38)	Fair quality but not up to this variety's usual standard.
Fair Maid of Devon. (Newton St. Cyres, Devon)	1.044 (25/10/37)	M. 0.80 T. 0.11 F. 2.8	(a) 1.030 (16/11/37) (b) 1.029 (26/4/38)	A cider with very little character; watery, with a hard acid flavour.
Farmer's Glory. (Hewish, Som.)	1.046 (25/10/37)	M. 0.83 T. 0.19 F. 1.9	(a) 1.030 (20/1/38) (b) 1.030 (26/4/38)	A cider with a peculiar flavour which was not generally liked.
Foxwhelp. (Wonastow, Mon.)	1.048 (29/10/37)	M. 0.68 T. 0.19 F. 4.0	(a) 1.030 (20/12/37) (b) 1.028 (26/4/38)	Fairly good, clean cider, useful for blending purposes but lacked character.
Hartisman. (Easton-in-Gordano, Som.)	1.055 (1/12/37)	M. 0.98 T. 0.16 F. 3.8	(a) 1.031 (29/1/38) (b) 1.029 (26/4/38)	Rather thin in flavour with a hard acidity.
Mediate. (Hewish, Som.)	1.045 (8/11/37)	M. 0.98 T. 0.13 F. 4.0	(a) 1.030 (13/12/37) (b) 1.029 (26/4/38)	A cider with very little character. The acid flavour was very penetrating.
Ponsford. (Thorverton, Devon)	1.050 (16/11/37)	M. 0.76 T. 0.09 F. 4.5	(a) 1.030 (7/1/38) (b) 1.026 (26/4/38)	Not very full in flavour, but it had a very attractive acid character.
Toogood Bitter. (Wells, Som.)	1.059 (29/11/37)	M. 0.83 T. 0.27 F. 3.7	(a) 1.030 (21/1/38) (b) 1.029 (26/4/38)	Fair cider but lacking in freshness of flavour.
White Hangdown. (Easton-in-Gordano, Som.)	1.052 (1/11/37)	M. 0.81 T. 0.12 F. 3.0	(a) 1.030 (4/2/38) (b) 1.030 (26/4/38)	Moderately good cider, fuller in flavour than many.
White Thorn Pippin. (Stonehouse, Glos.)	1.042 (9/11/37)	M. 0.83 T. 0.09 F. 5.5	(a) 1.030 (27/11/37) (b) 1.026 (26/4/38)	Particularly clean-flavoured cider but very thin.

COMPETITIVE VARIETIES.

CLASS 2B.—VARIETIES OF MEDIUM ACIDITY.					
Castle Farm Red. (Wells, Som.)	1.053 (19/11/37)	M.	0.64	(a)	1.026 (29/12/37)
		T.	0.14	(b)	1.025 (26/4/38)
		F.	6.7		
Hunts' White Sharp. (Easton-in-Gordano, Som.)	1.049 (1/12/37)	M.	0.62	(a)	1.026 (28/12/37)
		T.	0.15	(b)	1.025 (26/4/38)
		F.	3.7		
Improved Kingston Black. (Burghill, Hereford)	1.057 29/11/37)	M.	0.43	(a)	1.030 (10/1/38)
		T.	0.33	(b)	1.028 (26/4/38)
		F.	4.8		
Lambrook Pippin. (Barton St. David, Som.)	1.061 (19/11/37)	M.	0.60	(a)	1.030 (26/2/38)
		T.	0.30	(b)	1.030 (26/4/38)
		F.	2.5		
Lambrook Pippin. (Kingweston, Som.)	1.066 (1/12/37)	M.	0.58	(a)	1.030 (10/2/38)
		T.	0.24	(b)	1.029 (26/4/38)
		F.	4.4		
Langworthy. (Newton St. Cyres, Devon)	1.045 (25/10/37)	M.	0.50	(a)	1.030 (1/12/37)
		T.	0.14	(b)	1.028 (26/4/38)
		F.	4.5		
Langworthy. (Taunton, Som.)	1.040 (29/11/37)	M.	0.44	(a)	1.030 (17/1/38)
		T.	0.09	(b)	1.030 (26/4/38)
		F.	1.3		

Quite a pleasant cider but not very full in flavour.

A very thin flavoured cider.

A very good pleasant drink, but the tannin flavour was rather too pronounced.

A moderately good cider but a little too acid to drink unblended, and the tannin character was rather excessive.

Higher in quality than the previous sample; more character and less pronounced in tannin flavour.

Poor in flavour, much below the usual standard of this variety.

A good cider, very much better than the previous sample. Well-balanced flavour, soft and fruity.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (a) Time of Filtering. (b) Date of Judging. (April 26/38).	Notes on Ciders.
CLASS 2B.—Varieties of Medium Acidity.— <i>continued.</i>				
Lorna Doone. (Wellington, Som.)	1.059 (18/10/37)	M. 0.40 T. 0.29 F. 5.7	(a) 1.030 (13/11/37) (b) 1.029 (26/4/38)	Rather poor cider with a very hard, unpleasant tannin character.
Neverblight. (Arlingham, Gos.)	1.051 (16/11/37)	M. 0.57 T. 0.11 F. 5.7	(a) 1.030 (28/12/37) (b) 1.029 (26/4/38)	Very pleasant cider, making a well- balanced and attractive drink un- blended.
Neverblight. (North Cadbury, Som.)	1.048 (29/11/37)	M. 0.55 T. 0.10 F. 3.5	(a) 1.030 (19/1/38) (b) 1.028 (26/4/38)	Pleasant, clean flavoured cider but not so attractive as the previous sample.
Porter's Jersey. (East Lambrook, Som.)	1.061 (29/11/37)	M. 0.48 T. 0.33 F. 3.3	(a) 1.030 (1/2/38) (b) 1.029 (26/4/38)	Rather coarse in flavour with a tannin content too high for a drink unblended.
Royal George. (Easton-in-Gordano, Som.)	1.063 (18/10/37)	M. 0.52 T. 0.22 F. 4.7	(a) 1.030 (5/1/38) (b) 1.029 (26/4/38)	High quality cider with a full apple flavour and fruity aroma, making an attractive drink unblended.
Tale Sharp. (Honiton, Devon)	1.050 (2/12/37)	M. 0.58 T. 0.21 F. 5.2	(a) 1.030 (14/1/38) (b) 1.030 (26/4/38)	Only moderate quality, lacking character.
Woolston Spice. (North Cadbury, Som.)	1.042 (1/12/37)	M. 0.49 T. 0.11 F. 3.4	(a) 1.030 (8/1/38) (b) 1.029 (26/4/38)	A clean flavoured cider, but not very full and the acidity was too pronounced.

COMPETITIVE VARIETIES.

CLASS 3.—SWEET VARIETIES.					
Brown Sweet. (Hewish, Som.)	1.054 (16/11/37)	M.	0.28	(a) 1.024 (4/2/38)	Good quality cider which retained its fresh flavour after prolonged period in bottle.
		T.	0.16	(b) 1.024 (26/4/38)	
		F.	3.5		
Bunch Jersey. (Barton St. David, Som.)	1.046 (2/11/37)	M.	0.20	(a) 1.025 (27/11/37)	Fair quality cider but developed sickness later in the summer.
		T.	0.07	(b) 1.023 (26/4/37)	
		F.	6.0		
Cow Apple. (Hewish, Som.)	1.054 (1/12/37)	M.	0.32	(a) 1.025 (29/1/38)	A good sweet cider with an attractive apple character.
		T.	0.11	(b) 1.024 (26/4/38)	
		F.	3.2		
Dunkerton Sweet. (Dunkerton, Bath, Som.)	1.050 (12/11/37)	M.	0.22	(a) 1.025 (11/12/37)	Rather thin in flavour.
		T.	0.08	(b) 1.023 (26/4/38)	
		F.	7.5		
Slack-ma-Girdle. (Newton St. Cyres, Devon)	1.053 (29/11/37)	M.	0.28	(a) 1.025 (9/2/38)	Very good cider, full in flavour.
		T.	0.12	(b) 1.025 (26/4/38)	
		F.	2.3		
Sweet Alford. (Berkeley, Glos.)	1.048 (2/11/37)	M.	0.17	(a) 1.025 (28/12/37)	A very attractive fruity cider with a pleasing soft flavour.
		T.	0.09	(b) 1.025 (26/4/38)	
		F.	3.7		
Sweet Alford. (Arlingham, Glos.)	1.050 (2/11/37)	M.	0.19	(a) 1.025 (23/12/37)	A good cider but not quite so fresh in flavour as the previous sample.
		T.	0.09	(b) 1.022 (26/4/38)	
		F.	5.3		
Sweet Alford. (Thorverton, Devon)	1.050 (2/11/37)	M.	0.16	(a) 1.025 (2/2/38)	Very good cider; pleasant and rich in apple flavour.
		T.	0.12	(b) 1.025 (26/4/38)	
		F.	2.8		
Sweet Alford. (Pinhoe, Devon)	1.050 (2/11/37)	M.	0.17	(a) 1.025 (18/2/38)	Excellent fruity flavoured cider; very soft in character and with a good apple aroma.
		T.	0.13	(b) 1.025 (26/4/38)	
		F.	2.2		

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (a) Time of Filtering, (b) Date of Judging. (April 26/38).	Notes on Ciders.
CLASS 3.—SWEET VARIETIES—continued.				
Sweet Alford. (Newton St. Cyres, Devon)	1.050 (2/11/37)	M. 0.17 T. 0.12 F. 2.8	(a) 1.025 (25/2/38) (b) 1.025 (25/4/38)	Moderate quality; rather lacking character.
Sweet Alford. (Burghill, Hereford)	1.049 (2/11/37)	M. 0.19 T. 0.09 F. 3.4	(a) 1.025 (28/12/37) (b) 1.025 (26/4/38)	Similar to the previous sample.
Sweet Alford. (Honiton, Devon)	1.056 (8/11/37)	M. 0.20 T. 0.17 F. 2.5	(a) 1.025 (26/2/38) (b) 1.025 (26/4/38)	Good quality cider; full in flavour.
Taylor. (East Lambrook, Som.)	1.051 (29/11/37)	M. 0.32 T. 0.11 F. 3.5	(a) 1.025 (28/1/38) (b) 1.025 (26/4/38)	A very attractive cider with a pleasant apple flavour and good aroma.
Woodbine. (Charlton Adam, Som.)	1.057 (29/11/37)	M. 0.28 T. 0.14 F. 3.3	(a) 1.025 (19/2/38) (b) 1.025 (26/4/38)	A fair cider but not so soft in flavour as the Sweet Alford.
Woodbine. (Babery, Som.)	1.060 (1/12/37)	M. 0.37 T. 0.14 F. 5.2	(a) 1.025 (24/1/38) (b) 1.025 (26/4/38)	Not so good as previous sample; a little coarse in flavour.
Woodbine. (Taunton, Som.)	1.052 (2/12/37)	M. 0.24 T. 0.12 F. 3.3	(a) 1.025 (3/3/38) (b) 1.025 (26/4/38)	Pleasant neutral flavoured cider with a good fruity aroma.

COMPETITIVE VARIETIES.

BITTERSWEET VARIETIES.

CLASS 4A.—MILD BITTERSWEETS.

Broadleaf Norman. (Barton St. David, Som.)	1.058 (1/11/37)	M. 0.24 T. 0.20 F. 5.5	(a) 1.025 (1/1/38) (b) 1.025 (26/4/38)	Fairly good cider but a little coarse in flavour.
Brown Snout. (Babeary, Som.)	1.053 (29/11/37)	M. 0.33 T. 0.13 F. 3.7	(a) 1.025 (25/1/38) (b) 1.025 (26/4/38)	A pleasant cider with a delicate attractive flavour, but it was not full-flavoured.
Cadbury. (North Cadbury, Som.)	1.051 (1/12/37)	M. 0.24 T. 0.22 F. 4.2	(a) 1.025 (4/2/38) (b) 1.025 (26/4/38)	A full-flavoured cider with a pleasant bitter character.
Cummy Norman. (Barton St. David, Som.)	1.057 (16/11/37)	M. 0.20 T. 0.18 F. 5.7	(a) 1.025 (14/1/38) (b) 1.025 (26/4/38)	Fair quality cider but the tannin character was a little harsh.
Dove. (Charlton Adam, Som.)	1.049 (19/11/37)	M. 0.21 T. 0.30 F. 2.5	(a) 1.025 (10/2/38) (b) 1.025 (26/4/38)	A very good quality cider with an attractive, mild bitter flavour.
Dunkerton Beauty. (Dunkerton, Som.)	1.051 (16/11/37)	M. 0.15 T. 0.22 F. 2.4	(a) 1.025 (4/2/38) (b) 1.025 (26/4/38)	Very good cider of definite cider-house value although the tannin flavour was a little harsh.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) % Tannin (T) % and Rate of Fermentation (F).	Gravity at (a) Time of Filtering. (b) Date of Judging. (April 26/38).	Notes on Ciders.
CLASS 4A.—MILD BITTERSWEETS— <i>continued</i> .				
Dunkerton Bitter. (Dunkerton, Som.)	1.049 (16/11/37)	M. 0.19 T. 0.22 F. 4.0	(a) 1.025 (8/1/38) (b) 1.025 (26/4/38)	Not a pleasant cider; rather poor and coarse in flavour.
Hangdown. (Hewish, Som.)	1.052 (25/10/37)	M. 0.21 T. 0.22 F. 2.6	(a) 1.025 (4/2/38) (b) 1.025 (26/4/38)	Very good cider, soft and fruity in flavour with a very pleasing mild bitterness.
Hangdown. (Charlton Adam, Som.)	1.054 (29/10/37)	M. 0.21 T. 0.22 F. 5.0	(a) 1.025 (26/1/38) (b) 1.025 (26/4/38)	Only fair in quality; not up to the standard of the previous sample.
Perthyre. (Barton St. David, Som.)	1.055 (1/11/37)	M. 0.19 T. 0.23 F. 3.6	(a) 1.025 (22/1/38) (b) 1.025 (26/4/38)	Excellent fruity flavoured cider of useful ciderhouse value.
Perthyre. (Llanrothal, Mon.)	1.053 (8/11/37)	M. 0.27 T. 0.18 F. 6.7	(a) 1.027 (4/12/37) (b) 1.026 (26/4/38)	A good and useful cider but not up to the standard of the previous sample.
Perthyre. (Rockfield, Mon.)	1.054 (8/11/37)*	M. 0.24 T. 0.17 F. 6.0	(a) 1.025 (11/12/37) (b) 1.024 (26/4/38)	Rather thin in flavour and un- attractive.

COMPETITIVE VARIETIES.

CLASS 4B.—MEDIUM BITTERSWEETS.						
Broadleaf Jersey. (Babery, Som.)	1.057 (1/12/37)	M.	0.23	(a)	1.025 (8/1/38)	Not outstanding; only fair in quality.
		T.	0.29	(b)	1.024 (26/4/38)	
Broadleaf Jersey. (Charlton Adam, Som.)	1.056 (1/12/37)	F.	6.4	(a)	1.025 (7/1/38)	Fair quality cider but the tannin flavour was inclined to be coarse.
		M.	0.24	(b)	1.024 (26/4/38)	
Bryant's Bitter. (Taunton, Som.)	1.053 (2/12/37)	T.	0.27	(a)	1.023 (29/12/37)	Only moderate quality; rather lacking character.
		F.	7.5	(b)	1.022 (26/4/38)	
Chisel Jersey. (North Cadbury, Som.)	1.053 (1/12/37)	M.	0.26	(a)	1.025 (9/2/38)	The quality was spoilt by a very coarse tannin flavour.
		T.	0.23	(b)	1.025 (26/4/38)	
Dabinett. (West Lambrook, Som.)	1.052 (1/12/37)	F.	8.8	(a)	1.025 (8/3/38)	Good quality cider, full-bodied, and a useful ciderhouse blender.
		M.	0.22	(b)	1.025 (26/4/38)	
Dabinett. (Burghill, Hereford)	1.050 (1/12/37)	T.	0.35	(a)	1.025 (27/1/38)	Full-flavoured, aromatic cider, with a mellow tannin character.
		F.	3.6	(b)	1.024 (26/4/38)	
Tale Sweet. (Honiton, Devon)	1.060 (2/12/37)	M.	0.19	(a)	1.025 (12/3/38)	Very good fruity flavoured cider with a pleasing, soft tannin character
		T.	0.20	(b)	1.025 (26/4/38)	
Tremlett's Bitter. (Pinhoe, Devon)	1.050 (1/11/37)	F.	2.7	(a)	1.025 (25/1/38)	Poor in flavour; spoilt by a harsh tannin character.
		M.	0.15	(b)	1.025 (26/4/38)	
White Norman. (Norton Canon, Hereford)	1.055 (21/10/37)	T.	0.28	(a)	1.025 (16/11/37)	A very useful, rich and fruity cider.
		F.	4.3	(b)	1.022 (26/4/38)	
Yarlington Mill Jersey. (North Cadbury, Som.)	1.052 (1/12/37)	M.	0.21	(a)	1.025 (21/1/38)	Not outstanding; lacking in freshness of flavour.
		T.	0.25	(b)	1.024 (26/4/38)	

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (a) Time of Filtering. (b) Date of Judging. (April 26/38).	Notes on Ciders.
CLASS 4C.—FULL BITTERSWEETS.				
Granville Jersey. (East Lambrook, Som.)	1.053 (19/11/37)	M. 0.22 T. 0.34 F. 5.2	(a) 1.025 (1/1/38) (b) 1.023 (26/4/38)	A cider with a very coarse, un- pleasant tannin character.
Harry Master's Jersey. (North Cadbury, Som.)	1.060 (1/12/37)	M. 0.14 T. 0.29 F. 4.6	(a) 1.025 (8/2/38) (b) 1.024 (26/4/38)	Fairly good cider but lacking fullness of flavour.
Knotted Kernel. (Wonastow, Mon.)	1.069 (17/11/37)	M. 0.25 T. 0.33 F. 4.8	(a) 1.025 (19/3/38) (b) 1.025 (26/4/38)	Quality only moderately good; not up to the variety's usual standard.
Knotted Kernel. (Burghill, Hereford)	1.065 (17/11/37)	M. 0.27 T. 0.25 F. 4.9	(a) 1.025 (11/2/38) (b) 1.025 (26/4/38)	Very similar to the previous sample.
Red Jersey. (Charlton Adam, Som.)	1.064 (29/11/37)	M. 0.20 T. 0.42 F. 2.2	(a) 1.025 (23/2/38) (b) 1.025 (26/4/38)	A very good cider which undoubtedly stood out as one of the best in the group. The tannin flavour was full but very attractive.
Strawberry Norman. (Barton St. David, Som.)	1.054 (16/11/37)	M. 0.25 T. 0.30 F. 3.0	(a) 1.025 (12/2/38) (b) 1.025 (26/4/38)	Very fair cider but not very full in flavour.
Strawberry Norman. (Chaceley, Glos.)	1.061 (16/11/37)	M. 0.26 T. 0.40 F. 4.4	(a) 1.025 (3/2/38) (b) 1.025 (26/4/38)	Good cider with a pleasant bitter character; one of the best samples of this variety received for some time.
Tom Tanners. (Hewish, Som.)	1.063 (19/11/37)	M. 0.27 T. 0.56 F. 4.0	(a) 1.025 (9/2/38) (b) 1.025 (26/4/38)	The tannin character was extremely harsh and unpleasant.
Yellow Norman. (Rockfield, Mon.)	1.072 (2/12/37)	M. 0.22 T. 0.44 F. 6.0	(a) 1.025 (2/3/38) (b) 1.025 (26/4/38)	Good quality cider but its exception- ally pronounced tannin flavour made its blending quality doubtful.

COMPETITIVE VARIETIES.

CLASS 5.—PERRIES.		Notes on Perries.	
Barnet. (Portbury, Som.)	1.054 (21/10/37)	M. 0.34 T. 0.10 F. 4.4	(a) 1.030 (4/12/37) (b) 1.029 (26/4/38)
Blakeney Red. (Llantilio Crosseymy, Mon.)	1.042 (18/10/37)	M. 0.39 T. 0.11 F. 4.7	(a) 1.030 (3/11/37) (b) 1.030 (26/4/38)
Blakeney Red. (Portbury, Som.)	1.053 (18/10/37)	M. 0.38 T. 0.13 F. 3.5	(a) 1.030 (24/12/37) (b) 1.030 (26/4/38)
Blakeney Red. (Arlingham, Glos.)	1.051 (18/10/37)	M. 0.45 T. 0.09 F. 3.3	(a) 1.030 (29/12/37) (b) 1.030 (28/4/38)
Blakeney Red. (Langattock Lingoed, Mon.)	1.046 (21/10/37)	M. 0.38 T. 0.11 F. 3.4	(a) 1.030 (26/11/37) (b) 1.029 (26/4/38)
Blakeney Red. (Hendre, Monmouth)	1.049 (21/10/37)	M. 0.37 T. 0.09 F. 3.4	(a) 1.030 (23/12/37) (b) 1.029 (26/4/38)
Blakeney Red. (Norton Canon, Hereford)	1.053 (21/10/37)	M. 0.36 T. 0.09 F. 4.2	(a) 1.030 (24/12/37) (b) 1.030 (26/4/38)
Blakeney Red. (Byford, Hereford)	1.048 (21/10/37)	M. 0.33 T. 0.08 F. 3.6	(a) 1.031 (26/11/37) (b) 1.029 (26/4/38)
Butt. (Arlingham, Glos.)	1.054 (10/11/37)	M. 0.64 T. 0.15 F. 1.5	(a) 1.030 (4/4/38) (b) 1.030 (26/4/38)
Butt. (Hardwicke, Glos.)	1.054 (24/11/37)	M. 0.53 T. 0.18 F. 1.7	(a) 1.030 (17/3/38) (b) 1.030 (26/4/38)

Notes on Perries.

Pleasant but thin in flavour.

Good, clean delicate flavour but lacking character.

Fuller in flavour; very pleasant light drink.

Attractive, clean in flavour and aromatic.

Fairly good but not quite as fresh in flavour as previous samples.

Very attractive perry with a delicate fruity flavour.

Pleasant but not very full in flavour.

Good flavour and fuller than many.

Fair quality with a good astringency.

Rather hard in flavour.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (a) Time of Filtering. (b) Date of Judging. (April 26/38).	Notes on Perries.
CLASS 5.—PERRIES—continued.				
Butt. (Stonehouse, Glos.)	1.057 (24/11/37)	M. 0.53 T. 0.18 F. 1.7	(a) 1.031 (11/4/38) (b) 1.031 (26/4/38)	Moderately good but with a very pronounced astringent flavour.
Butt. (Ashleworth, Glos.)	1.054 (24/11/37)	M. 0.47 T. 0.15 F. 2.0	(a) 1.030 (30/3/38) (b) 1.030 (26/4/38)	Clean in flavour but the acid character was too pronounced.
Oldfield. (Stonehouse, Glos.)	1.061 (10/11/37)	M. 0.72 T. 0.12 F. 2.3	(a) 1.030 (24/3/38) (b) 1.030 (26/4/38)	Lacking in character and too acid in flavour.
Oldfield. (Holmer, Hereford)	1.061 (10/11/37)	M. 0.67 T. 0.09 F. 1.8	(a) 1.030 (30/3/38) (b) 1.030 (26/4/38)	Fair in quality but spoilt by a pronounced acid flavour.
Oldfield. (Spetchley, Wores.)	1.060 (24/11/37)	M. 0.54 T. 0.10 F. 2.3	(a) 1.030 (17/3/38) (b) 1.030 (26/4/38)	Quite a good flavour but again spoilt by excessive acid flavour.
Port. (Hendre, Mon.)	1.047 (1/11/37)	M. 0.93 T. 0.11 F. 4.0	(a) 1.030 (23/12/37) (b) 1.028 (26/4/38)	Rather thin in flavour with a very keen, raw acid character.
Swan Egg. (Llantilio (Yossemy, Mon.))	1.038 (12/10/37)	M. 0.25 T. 0.08 F. 6.0	(a) 1.030 (22/10/37) (b) 1.028 (26/4/38)	Very poor perry; of no vintage value.

COMPETITION CIDERS AND PERRIES, 1937 - 1938.

JUDGES' AWARDS.

Class 1. KINGSTON BLACK (7 Entries). 1 Prize.

First Prize	E. T. Bryant, Taunton, Som.
Reserve	H. C. Davis, Hewish, Som.
Very Highly Com'ded	B. R. Davies, Wonastow, Mon.

Class 2A. SHARP VARIETIES (10 Entries). 2 Prizes. *Variety.*

First Prize	B. R. Davies, Wonastow, Mon. ..	Foxwhelp.
Second Prize	Mental Hospital, Burghill, Hereford	Cap of Liberty.
Reserve	M. J. Huggins, Thorverton, Devon	Ponsford.
Highly Commended	H. C. Davis, Hewish, Som. ..	Farmer's Glory.
.. ..	F. R. Bullock, Easton-in-Gordano, Som.	Hartisman.

Class 2B. MEDIUM SHARP VARIETIES (14 Entries). 3 Prizes.

First Prize	F. R. Bullock, Easton-in-Gordano, Som.	Royal George.
Second Prize	W. P. Merrett, Arlingham, Glos.	Neverblight.
Third Prize	J. Maunder, Kingweston, Som. ..	Lambrook Pippin.
Reserve	Mental Hospital, Burghill, Hereford	Improved Kingston Black.
Very Highly Com'ded	E. T. Bryant, Taunton, Som. ..	Langworthy.
.. ..	S. H. Osborn, North Cadbury, Som.	Neverblight.

Class 3. SWEET VARIETIES (16 Entries). 3 Prizes.

First Prize	F. Vincent, Pinhoe, Devon ..	Sweet Alford.
Second Prize	A Chamberlayne, Berkeley, Glos.	Sweet Alford.
Third Prize	M. J. Huggins, Thorverton, Devon	Sweet Alford.
Reserve	W. Porter, East Lambrook, Som.	Taylor.
Very Highly Com'ded	E. T. Bryant, Taunton, Som. ..	Woodbine.
Highly Commended	S. H. Walters, Newton St. Cyres, Devon	Slack-ma-Girdle.
Commended	T. J. Frampton, Barton St. David, Som.	Bunch Jersey.

Class 4A. MILD BITTERSWEETS (12 Entries). 3 Prizes.

First Prize	T. J. Frampton, Barton St. David, Som.	Perthyre (Belle Norman).
Second Prize	G. P. Hallett, Charlton Adam, Som.	Dove.
Third Prize	H. C. Davis, Hewish, Som. ..	Hangdown.
Reserve	S. H. Osborn, North Cadbury ..	Cadbury.
Very Highly Com'ded	E. R. Clark, Babeary, Som. ..	Brown Snout.
.. ..	G. Date, Dunkerton, Som. ..	Dunkerton Beauty.

Class 4B. MEDIUM BITTERSWEET (10 Entries). 2 Prizes.

First Prize	Mental Hospital, Burghill, Hereford	Dabinett.
Second Prize	H. Daniel, Honiton, Devon	Tale Sweet.
Reserve	P. T. Prosser, Norton Canon, Hereford	White Norman.
Very Highly Com'ded	R. W. Wyatt, West Lambrook, Som.	Dabinett.
Highly Commended	S. H. Osborn, North Cadbury, Som.	Yarlington Mill Jersey

*Class 4C. FULL BITTERSWEETS (9 Entries). 2 Prizes.**Variety.*

First Prize	G. P. Hallett, Charlton Adam, Som.	Red Jersey.
Second Prize	H. A. Lane, Chaceley, Glos.	Strawberry Norman.
Reserve	D. A. & R. R. Watkins, Rockfield, Monmouth	Yellow Norman.
Very Highly Com'ded	S. R. Plumley, Barton St. David, Som.	Strawberry Norman.
Commended	B. R. Davies, Wonastow, Mon.	Knotted Kernel.
"	Mental Hospital, Burghill, Hereford	Knotted Kernel.

Class 5. PERRIES. (17 Entries). 3 Prizes.

First Prize	E. Wood, Hendre, Monmouth	Blakeney Red.
Second Prize	W. Wootton, Byford, Hereford	Blakeney Red.
Third Prize	J. A. Hurditch, Portbury, Som.	Blakeney Red.
Reserve	R. G. W. Berkeley, Spetchley Park, Worcs.	Oldfield.
Very Highly Com'ded	W. P. Merrett, Arlingham, Glos.	Blakeney Red.
" " "	P. T. Prosser, Norton Canon, Hereford	Blakeney Red.
Highly Commended	J. A. Hurditch, Portbury, Som.	Barnet.

SPECIAL PRIZES.

Special Prizes awarded for the best SHARP, SWEET and BITTERSWEET VARIETIES which had not previously obtained a prize in these Competitions :—

		<i>Variety.</i>
SHARP VARIETY	W. P. Merrett, Arlingham, Glos.	Neverblight.
SWEET VARIETY	T. J. Frampton, Barton St. David, Som.	Bunch Jersey.
BITTERSWEET VARIETY	G. P. Hallett, Charlton Adam, Som.	Broadleaf Jersey.

THE CIDER COMPETITIONS SCHEME, 1937 - 1938.

AWARDS FOR FRUIT CONDITION.

By P. T. H. PICKFORD and G. T. SPINKS.

For the second year in succession prizes were awarded for fruit condition in the Cider Competitions. In the report on the 1936-1937 Competitions, it was pointed out that fruit is often delivered to cider-makers in poor condition, with resulting adverse effects on the quality and yield of cider, and it was thus thought that the award of prizes for fruit condition would encourage growers to pay more attention to this point.

In the 1937-1938 Competitions, the same objects were kept in mind and competition entries were judged on the same system as that adopted in the previous year. A summarized account of the procedure and a brief review of the results and conclusions are given below.

Competition Procedure and Awards.

Each sample of fruit entered for the competition was examined as soon as possible after its receipt and was awarded marks according to the following scale of points :—

					<i>Maximum Points.</i>
Purity of Variety	..	..	..	..	10
Freedom from Rotten Fruit	..	..	..	..	30
„ „ Broken Skin	..	..	..	..	30
„ „ Bruising	..	..	..	..	10
„ „ Extraneous Matter	..	..	..	..	20
					—
					100
					—

The number of entries of fruit received and judged was 95, of which 17 were perry pears and the remainder cider apples. The total number of entries was less than half that received in the previous year, probably owing to the comparatively small crop of fruit in 1937.

In making the awards due consideration was given to the relative susceptibility to bruising of varieties, to the greater difficulty of delivering pears in good condition, and to the fact that some fruit travelled long distances by rail while other consignments had only short direct journeys by road. No competitor was penalized, therefore, on account of the sort or variety of fruit entered, or owing to the method or distance of transport.

The prize for the consignment of fruit received in the best condition was awarded to:—

Mental Hospital, Burghill, Hereford.

Additional prizes for fruit received in good condition were awarded to:—

H. C. Davis, Hewish, Somerset.

S. H. Osborn, North Cadbury, Somerset.

Review of Results.

Points of significant interest in the list of marks awarded are dealt with below, firstly under the separate categories in which marks were lost, and then more generally.

Purity of Variety. Out of the 95 entries, 84 received full marks for being true to name and free from any mixture of other varieties. In six cases only one mark was lost, but two received no marks for purity and were disqualified, as they contained more than 10 per cent. of other varieties. The average mark obtained was 9.6 out of a possible 10.

Rotten Fruit. The average mark obtained in this section was 27.9 out of a maximum of 30. Full marks were earned by 16 entries, which were entirely free from rotten fruit, while in 73 other cases 25 marks or more were awarded. The marks were below 20 for 6 entries only, of which three were pears. The worst sample, a pear, received only 14 marks.

Broken Skin. Under this category the average marks obtained amounted to 27.4 out of a possible 30. Only four entries gained full marks, but in 87 cases the marks were 25 or over. Eight entries received less than 25 marks, the lowest figure being 20.

Bruising. The average mark awarded was 7.4 out of a possible 10. No entry was entirely free from bruising, but in 12 cases 9 marks were given. Twenty-one entries received less than 7 marks, the worst sample receiving only 4 marks.

Extraneous Matter. The average mark was 19.6 out of a maximum of 20, almost all the samples being very clean. Full marks were obtained by 59 entries, and the lowest mark awarded was 18.

Total Marks for all Characters. The average of the total marks obtained by the 95 entries was 91.9 out of a possible 100. The best sample obtained 98.5 marks, and 17 others received more than 95 marks. At the other end of the scale only 7 entries received less than 86 marks, the worst sample, a pear, obtaining only 75 marks.

Varietal Features. The comparatively small number of entries of any one variety made it difficult to correlate condition with the variety of fruit. It was, however, evident that late and hard varieties were received in better condition, as regards bruising, injury and rotten fruit, than earlier and softer varieties, but it also appeared that the condition of any one variety depended on the care taken in the harvesting and despatching of the fruit.

Pears, on the whole, arrived in rather poorer condition than apples, and samples of varieties such as Blakeney Red were usually inferior to those of Oldfield and Butt, but here again the condition of a variety was evidently influenced by the care exercised by the grower.

General Observations.

The general standard of the entries was distinctly higher in every respect than in the previous year. While this might be due to the stimulus and experience gained in the first competition, it appears probable that the improvement was due mainly to the better weather conditions at harvesting time in the second year. In 1936 most of the fruit was gathered during a wet period, while in 1937 dry weather favoured the collection of the fruit in a clean condition, with little injury or bruising, and consequently with less rot.

The best entries received were again in really excellent condition, but it appeared that the amount of rotten fruit, bruising and broken skin in some of the inferior samples could have been avoided by more careful harvesting and, in some cases, by sending the fruit before it had become over-ripe.

FERMENTATION CONTROL OF CIDERS BY THE CENTRIFUGE METHOD.

RELATIONSHIP BETWEEN CHANGES IN NITROGEN CONTENT IN JUICES AND CIDERS AND THE SUBSEQUENT RATES OF FERMENTATION.

By VERNON L. S. CHARLEY.

The previous contributions to the general subject of the control of the fermentation of ciders by the centrifuge which have appeared in the Annual Reports of the Long Ashton Research Station (1), (2), (3) were mainly concerned with the effect of the centrifuge on the rate of fermentation, and no attempts were made to determine the exact nature of the mechanism whereby the check in fermentation was achieved. One series of carefully controlled experiments was discussed in the 1933 Report, but the conditions were not such as to enable the centrifuge to be used to the greatest advantage, due to the naturally slow rate of fermentation of the juice used.

In the 1934-35 season five different blends were specially chosen, including two which were made from mixed culinary apple juices which normally experience very rapid fermentations. The juices were centrifuged at definite intervals of specific gravity, and nitrogen determinations on the uncentrifuged and centrifuged ciders carried out. In certain cases, the nitrogen content of the material deposited in the bowl of the centrifuge was also ascertained.

No attempt was made to obtain a definite "balance sheet" for the total nitrogen constituents in the juices or ciders during the various treatments. Attention was paid chiefly to the nitrogen contents of the liquors which actually passed through the centrifuge bowl. The lees were not centrifuged nor were they considered in the experimental work or calculations, and although the deposits remaining in the bowl were examined in most cases, it was not the intention of the experiments to correlate the reduction in nitrogen contents in the ciders with the amounts of nitrogen found in the solids deposited in the bowl. The results obtained are presented in the experimental section of this article.

Experimental.

Five experimental blends of juices were used for the investigations. The analyses are given below :—

Type of Fruit.		Specific Gravity.	Acidity (as Malic Acid) per cent.	Tannin per cent.	Rate of Fermentation.
Blend No. 1.	Bramley's Seedling ..	1.045	0.99	0.11	12.9
" "	2. Mixed culinary and cider windfall apples	1.048	0.78	0.15	9.7
" "	6. Mixed cider fruit A ..	1.048	0.51	0.13	7.0
" "	9. " " " B ..	1.051	0.41	0.15	3.2
" "	11. " " " C ..	1.050	0.40	0.19	4.5

The general procedure planned for the five separate experiments was as follows. The blended, fresh juices were thoroughly mixed and filled into a series of 4-8 pipes or hogsheads, according to the volume of juice available. One pipe or hogshead of the juice was immediately centrifuged through the Sharples super-centrifuge at a rate of 100 gallons an hour, and the separated liquor collected in a clean, steamed cask and allowed to ferment. This treated juice, after fermentation, was further centrifuged at later stages when the specific gravity had fallen either 5 or 8 points from the gravity at which the previous centrifuging had taken place, this procedure continuing until a desired gravity was reached. The other casks of ciders were centrifuged for the first time at progressively later stages, when the original gravity had fallen 10, 15, 20 or 25 points in certain cases or 8, 16, 24 points in others. In these ciders, also, each bulk of liquor was again passed through the centrifuge at later stages when fermentation had further reduced the gravity by 5 or 8 points respectively. The following table illustrates the method as applied to six casks of Blend No. 2 of original gravity 1.048 and a final gravity of 1.016, the interval between the centrifugings being approximately 5 points. The departures from the exact gravity intervals are due to various causes, amongst them being the inability to deal with all the fermenting casks of cider which needed treatment simultaneously.

SPECIFIC GRAVITIES AT WHICH CIDERS IN BLEND 2
WERE CENTRIFUGED.

Cask 1	..	1.048	..	1.045	..	1.037	..	—
” 2	..	—	..	1.043	..	1.037	..	1.031
” 3	..	—	..	—	..	1.037	..	—
” 4	..	—	..	—	..	—	..	1.025
” 5	..	—	..	—	..	—	..	1.020
” 6	..	—	..	—	..	—	..	1.016

With certain juices it was not possible to carry out this plan exactly as intended, for the initial centrifuging treatments, whether of the fresh juice or the fermenting liquors, checked the fermentation to such an extent that the necessary subsequent fall in gravity did not occur and consequently no further centrifuging was done. This was most noticeable in Blend 11, where no cider was centrifuged more than once.

The nitrogen data were obtained by taking samples of the juices or ciders from the casks before centrifuging, and from the outlet of the centrifuge when half the bulk of cider had been centrifuged. Aliquots of these samples were weighed, evaporated in vacuo to a syrup consistency in a Kjeldahl flask, and the usual wet digestion and distillation method used to determine the total nitrogen. Triplicate determinations were carried out.

Finally, the deposit remaining in the centrifuge bowl was collected as completely as possible, weighed, and total nitrogen determined. Dry weight data were obtained on the deposits. In some of the centrifuging treatments at lower gravities which had been preceded by a series of earlier treatments, it was not possible to remove all the deposit from the bowl with a scraper on account of its very liquid consistency; in these instances the bowl was thoroughly washed out with water and the washings collected, well mixed and an aliquot taken and the total nitrogen determined. The result was then added to the figures obtained for the solid residues.

Results and Discussion.

The graphs in Figures 1-5, given at end of this article, illustrate the changes in specific gravity in the five experimental blends. The various centrifuging treatments are identified in the graphs by a series of letters which, by reference to the appropriate column in Tables I—V, enable the nitrogen data for each individual centrifuging treatment to be ascertained. The significance of

the experimental data is discussed in separate sections dealing with specific gravity changes and nitrogen determinations in ciders and centrifuge deposits.

Specific Gravity Changes.

The aim of the investigation was to correlate the changes in nitrogen content in the juices or ciders with the behaviour of the centrifuged products with respect to further fermentation, but the general nature of the progress of the fermentation of the various blends may be conveniently discussed first. It was desired to keep all the ciders at a gravity of at least 1.020, and as much above this figure as proved to be practicable.

Blend 1 was composed entirely of windfall culinary apple juices with a preponderance of Bramley's Seedling. The centrifuging of the fresh juice appeared to have little effect on the rate of fermentation, and three subsequent centrifuging operations gave only slightly better results. A final passage through the centrifuge at a gravity of 1.021 held the juice at a gravity of 1.016, although there was a rapid drop of three points immediately after the last centrifuge treatment, as indicated in the top graph in Figure 1. The fermentation of the fresh juice in the uncentrifuged sample appeared to show a "period of induction," *i.e.* for the cider to remain apparently quiescent for two or three days and then to develop suddenly a rapid fermentation. (Owing to the scale, this very slow initial fermentation is not indicated in the graph). Indeed, the gravity had fallen to 1.020 before it was possible to treat the juice. A very much more effective check in the rate of fermentation was achieved in this case and the cider only lost a further three points of gravity during four months. It is evident that with a juice of this type an early series of centrifugings at quick intervals is not effective, and that it is necessary to allow a large crop of yeast to form previous to its removal by the centrifuge.

Blend 2 was composed of a mixture of culinary apples and mixed cider apples, all being obtained from the Long Ashton orchards. The fermentation of the uncentrifuged casks of fresh juice was again very rapid. For example, the cider in cask 5 had fallen from an initial gravity of 1.048 to a gravity of 1.016 in ten days. Centrifuging the fresh juice, however, was somewhat more effective than in Experiment 1. This is illustrated by the more horizontal nature of the top graph in Figure 2. Two further centrifugings at gravities of 1.043 and 1.036 succeeded in checking the fermentation and the final product retained its sweetness to a marked degree.

The juice which was allowed to ferment to a gravity of 1.036 before being separated (No. 8) lost a further three points in a few days, but subsequently settled down into a fairly stable condition. Centrifuging the juice at lower gravities afforded practically complete control of fermentation over the period indicated.

Blend 6 was made from mixed Somerset cider apples. Here the normal rate of fermentation was less excessive and the centrifuge gave correspondingly better results. The second bulk of juice, centrifuged for the first time at 1.040, had not fallen a further five points within the next five months, whilst the third juice, centrifuged for the first time at 1.032, lost five points of gravity and was then centrifuged again (Fig. 3). Good fermentation control was obtained when juices were centrifuged for the first time at gravities of 1.025 and 1.016.

Blend 9 presented two features which exhibited a remarkable divergence from the normal behaviour of centrifuged ciders as illustrated in the previous graphs. It will be seen that the second cask of juice was first centrifuged at 1.046 and again at 1.041 shortly afterwards. This second treatment resulted in a complete check to fermentation for a considerable period and a gravity of 1.040 was maintained in the samples in bottle until July 1935—nine months after the juice was centrifuged. A further point of interest is the sudden loss of gravity in the cider in the first cask after the third centrifuging. The fermentation had been considerably retarded by the second centrifuging at a gravity of 1.047 (Fig. 4, B), but subsequent to the third separation at 1.042 (Fig. 4, C) the cider lost gravity at an accelerated rate. Some accidental infection in the receiving cask is probably the reason for this behaviour of the liquor. Cider centrifuged at a gravity of 1.036 on the tenth day of the experiment (Fig. 4, J) possessed a gravity in cask of 1.031 110 days later. Treatment of ciders at lower gravities gave correspondingly greater security from after-fermentation.

The final experiment, No. 11, again utilised mixed cider fruit. The results in this case were remarkable. In no case was it necessary to centrifuge any of the juices or ciders a second time. Even when the fresh juice itself was centrifuged direct from the press the primary fermentation was not sufficient to warrant a further passage through the centrifuge. Four months after the commencement of the experiments the ciders in the four casks had specific gravities of 1.044, 1.037, 1.033 and 1.025. The fall in gravities subsequent to the various centrifuge treatments had only amounted to 3, 3, 1, 0 points respectively. The first product contained

only 0.4% of alcohol and was consequently suitable for sale as a non-alcoholic product.

The general conclusions confirm those of the previous report. It is, in general, advisable to allow a fall in gravity of about 10 or 15 points before attempting to use the centrifuge. The remarkable result of Experiment 11, cask 1, is quite unique, and will be discussed later from the point of view of nitrogen content.

Changes in Nitrogen Content due to Centrifuging.

The nitrogen contents of fresh or centrifuged juices and ciders are given in Tables I—V.

Experiment 1.

(Figure 1, Table I). The excessive rate of fermentation of the culinary juice used in this series was reflected in the high nitrogen content in the fresh juice (0.0180%). This represents the highest percentage of nitrogen that has ever been found in any apple juice examined for this constituent in the course of these or any other investigations at the Long Ashton Station. Very remarkable changes in nitrogen content resulted from the centrifuging of the first cask of juice at various gravities. Although the centrifuging of the fresh juice did not effect any change in the nitrogen content, the second treatment at a gravity ten points lower than the fresh juice resulted in a considerable removal of this element. The juice at gravity 1.035 prior to centrifuging contained considerably less nitrogen than was present in the centrifuged fresh juice (0.018%), and this figure of 0.0123% was reduced by centrifuging to 0.004%. Such important changes in the nitrogen content of the juices would have been expected greatly to retard the rate of fermentation, but the top graph in Fig. 1 indicates that this was not the case. Only slight removal of nitrogen was effected by the three following centrifugings, but the last treatment stabilised the cider at a gravity of 1.020.

The second curve illustrates the behaviour of a juice which was not centrifuged in the fresh state and which fermented at a rapid rate from a gravity of 1.045 to 1.020 in $3\frac{1}{2}$ days. At this lower gravity the cider was centrifuged. Before treatment at a gravity of 1.020 the cider contained 0.0159% of nitrogen (Fig. 1, F). This contrasts very markedly with the data for the second centrifuging of the first cask of juice (Fig. 1, B) where, after a fall of only ten points in gravity the nitrogen had fallen from 0.018% to 0.0123%.

The probable explanation for this apparent discrepancy is that at the time of the centrifuging of the cider in the second cask of juice, the fermentation was proceeding with such vigour that there was no considerable settlement of yeast material, and that when a sample was taken from the middle of the cask the even distribution of yeast throughout the bulk of the juice resulted in a high proportion of yeast being removed in the sample. In the other case, it is probable that the less vigorous fermentation which was proceeding when the centrifuge treatment was adopted had allowed a deposition of yeast cells to occur and consequently the sample taken from the cask would be without its due proportion of the quantity of yeast material constituting the lees.

The removal of nitrogen from the uncentrifuged juice or ciders by the various centrifugings is given below (the letters refer to Fig. 1).

CASK 1.					CASK 2.	
A	B	C	D	E	F	G
Nil.	67.5%	Nil.	50.0%	Nil.	75.0%	Not determined.

Experiment 2.

(Figure 2, Table II). The original nitrogen content is again higher than is usually found in cider apple juices, and the centrifuging of the fresh juice reduced the nitrogen from 0.0111% to 0.0067%. There was again a tendency for the vigorously fermenting juices to contain a high percentage of nitrogen (Fig. 2, κ). Apart from this the nitrogen data do not show any other special features. The centrifuging treatments in every case removed appreciable quantities of nitrogen and the largest reductions were invariably obtained with ciders which had experienced the most considerable falls in gravity before being centrifuged. (G, H, J, K).

Experiment 6.

(Figure 3, Table III). The nitrogen content of the fresh juice is lower than in the two preceding juices. Centrifuging of the fresh juice did not materially affect its nitrogen content and no very considerable differences are shown by the other figures, the nitrogen contents of the final centrifuged cider being similar to those in Experiments 1 and 2.

Experiment 9.

(Figure 4, Table IV). The nitrogen data are similar to those for the preceding experiment. Very low nitrogen contents are

shown early in the treatment of the various juices and fermentation was much slower.

Experiment 11.

(Figure 5, Table V). The nitrogen value for the fresh juice is typical of that for a mixed cider juice. All the percentages found for the centrifuged and uncentrifuged juices and ciders were very low.

Discussion of Nitrogen Data.

The final check in fermentation (shown in the figures by the curves becoming practically horizontal) occurred, in nearly all cases, when the nitrogen content was in the neighbourhood of 0.004%, but there are several cases where centrifuged ciders which contained approximately this percentage of nitrogen commenced to ferment again within a short time. It is possible that nitrogen may be present partly in a form which is not assimilable by the yeasts, and that the inclusion of this type of nitrogenous material in the analyses may preclude any very close correlation between total nitrogen content and the subsequent behaviour of the cider.

A critical examination of the data for nitrogen contents in the various juices or fermenting ciders in the five experimental blends indicates that the actual results obtained by the centrifuge treatment are not entirely explained by the total nitrogen figures. Although the data for the nitrogen contents of the materials collected in the bowl are not given here the figures ranged from 8% to 35%. It is possible that more light would be thrown on the subject by a consideration of various fractions of nitrogenous materials as is now done for other biological research. This work is now being undertaken.

Again, the possibility of other mineral elements besides nitrogen being involved in the nutrition of the yeasts and thus contributing to the complexity of the problem must not be overlooked. Phosphates are of great importance in the metabolism of yeast cells and as the apple juices contain about 0.007% of P_2O_5 , it is possible that the phosphate contents of the juices may have an important influence on the rate of fermentation. The data show, however, that centrifuging treatments remove varying amounts of nitrogenous materials from the ciders, and that these treatments very considerably retard the fermentation rates.

Summary.

1. Apple juices of widely differing rates of fermentation were centrifuged at varying specific gravity intervals.

2. Effectiveness of fermentation control by the centrifuge method was correlated with the nitrogen content of the fresh juice (0.018%—0.0053%); high-nitrogen juices respond to centrifuging to a lesser degree than those with lower percentages of nitrogen. Varying amounts of nitrogen were removed by the centrifuge treatment.

3. With a juice containing a low nitrogen percentage (0.0053%) a single centrifuging at various lower gravities used was sufficient to retain the different ciders in a stable condition.

4. Whilst the centrifuging of juices direct from the press removed very variable amounts of nitrogenous compounds, the passage through the centrifuge of fermenting ciders effected the removal of amounts up to 96% of the total nitrogen.

REFERENCES.

- (1) BARKER, B. T. P. and GROVE, O. "The Clarification of Ciders by the Centrifuge Method—I." *Ann. Report Agric. and Hort. Res. Sta., Long Ashton, Bristol*, p. 199, 1930.
- (2) BARKER, B. T. P. and GROVE, O. "The Clarification of Ciders by the Centrifuge Method—II." *Ibid.*, p. 168, 1931.
- (3) CHARLEY, V. L. S. "Fermentation Control of Ciders by the Centrifuge Method." *Ibid.*, p. 145, 1933.

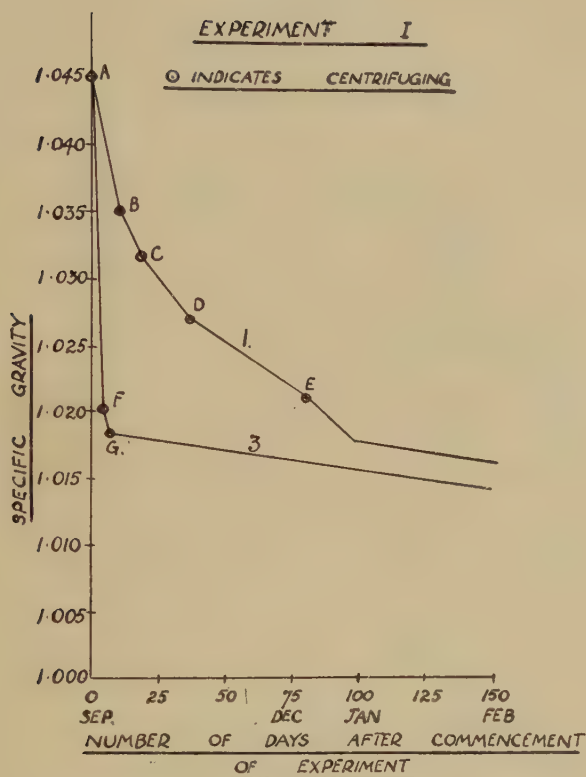


FIG. 1.

TABLE I.
EXPERIMENT I.

RELATIONSHIP BETWEEN NITROGEN CONTENTS IN CENTRIFUGED AND
UNCENTRIFUGED CIBERS.

Cask No.	1.						3.
Identification letter of centrifuging treatment	A	B	C	D	E	F	G
Specific gravity at centrifuging	1.045	1.035	1.032	1.027	1.022	1.020	1.018
Nitrogen per cent. before centrifuging	0.0180	0.0123	0.007	0.006	0.004	0.0159	—
Nitrogen per cent. after centrifuging	0.0180	0.0040	0.007	0.003	0.004	0.004	—
Percentage removal of nitrogen	Nil	67.5	Nil	50.0	Nil	75.0	—

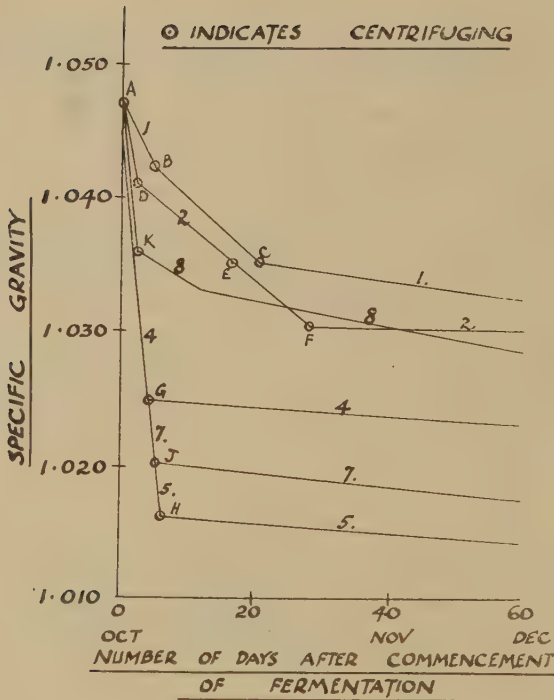
EXPERIMENT 2.

FIG. II.

TABLE II.

EXPERIMENT 2.

RELATIONSHIP BETWEEN NITROGEN CONTENTS IN CENTRIFUGED AND UNCENRIFUGED CIDERS.

Cask No.	1.			2.			4.	5.	7.	8.
Identification letter of centrifuging	A	B	C	D	E	F.	G	H	J	K
Specific gravity at centrifuging ..	1.048	1.043	1.036	1.041	1.030	1.030	1.025	1.016	1.020	1.036
Nitrogen per cent. before centri-fuging ..	0.0111	—	0.0025	—	—	0.0036	0.0089	0.0074	0.0086	0.0113
Nitrogen per cent. after centri-fuging ..	0.0067	—	0.0024	—	—	0.0031	0.0037	0.0031	0.0027	0.0040
Percentage removal of nitrogen ..	39.6	—	4.0	—	—	14.0	58.4	58.1	63.3	64.8

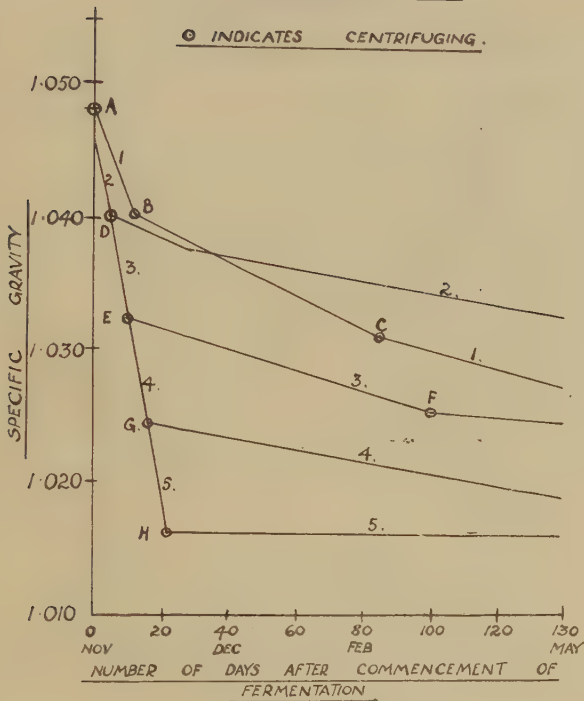
EXPERIMENT 6

FIG. III.

TABLE III.

EXPERIMENT 6.

RELATIONSHIPS BETWEEN NITROGEN CONTENTS OF CENTRIFUGED
AND UNCENRIFUGED CIDERS.

Cask No.	1..		2.	3.		4.	5.	
Identification letter of centrifuging ..	A	B	C	D	E	F	G	H
Specific gravity at centrifuging ..	1.048	1.040	1.032	1.040	1.032	1.024	1.024	1.016
Nitrogen per cent. before centrifuging ..	0.000	0.010	—	0.0065	0.0048	—	0.0050	0.0043
Nitrogen per cent. after centrifuging ..	0.008	0.0067	—	0.0058	0.0045	—	0.0029	0.0025
Percentage removal of nitrogen ..	11.1	33.3	—	10.7	6.2	—	40.2	41.9

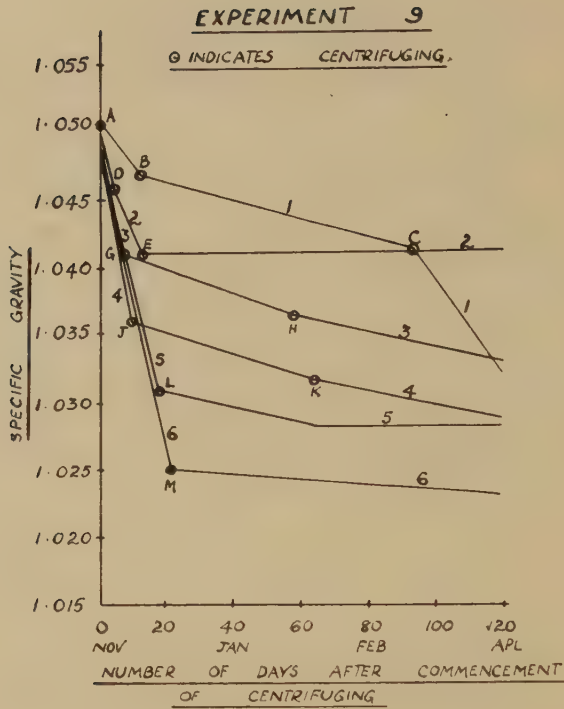


TABLE IV.

EXPERIMENT 9.

RELATIONSHIPS BETWEEN NITROGEN CONTENTS IN CENTRIFUGED
'AND UNCENTRIFUGED CIDERS.

Cask No.	1.			2.		3.		4.		5.	6.
Identification letter of centrifuging ..	A	B	C	D	E	G	H	J	K	L	M
Specific gravity at centrifuging ..	1.050	1.046	1.041	1.046	1.041	1.041	1.036	1.036	1.031	1.031	1.025
Nitrogen per cent. before centrifuging	0.0061	0.0044	—	—	0.0032	0.0033	0.0021	0.0029	—	0.0025	0.0022
Nitrogen per cent. after centrifuging	0.0045	0.0042	—	—	0.0028	0.0031	0.0021	—	—	0.0021	0.0022
Percentage removal of nitrogen ..	26.3	4.8	—	—	12.5	6.36	Nil	—	—	16.0	Nil

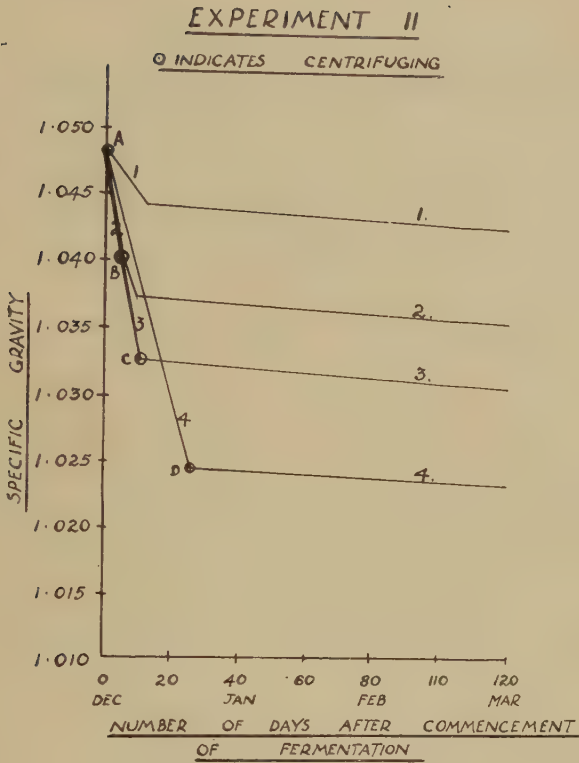


FIG. V.

TABLE V.
EXPERIMENT 11.

RELATIONSHIP BETWEEN NITROGEN CONTENTS IN CENTRIFUGED
AND UNCENRIFUGED CIDERS.

Cask No.	1.	2.	3.	4.
Identification letter of centrifuging	A	B	C	D
Specific gravity at centrifuging ..	1.048	1.040	1.032	1.024
Nitrogen per cent. before centrifuging	0.0053	0.0038	0.0041	0.0016
Nitrogen per cent. after centrifuging	0.0041	0.0024	0.0024	0.0012
Percentage removal of nitrogen ..	22.6	36.9	41.5	25.0

INVESTIGATIONS ON FRUIT PRODUCTS.

XV.—EXPERIMENTS ON THE PRODUCTION
OF UNFERMENTED APPLE JUICE.

1938.*

By VERNON L. S. CHARLEY and V. E. SILLS.

The previous paper (1) in this series, which appeared in last year's Annual Report, dealt with the results of four years' experiments on various aspects of the production of apple juice. A new sequence of processes, including maceration and deaeration, was introduced, and as a result of this contribution many requests for advice on specific points in the processing were received during the summer of 1938. It soon became obvious that the small laboratory apparatus used in the 1934-8 investigations was planned on too small a scale to enable detailed advice to be given to firms contemplating a considerable output of juice, and consequently an attempt was made to develop commercial machines which could be used to carry out the recommended processes. Through the co-operation of the Aluminium Plant & Vessel Co., Ltd., Wandsworth, London, a pasteurizer was placed at the disposal of the Fruit Products Section and was first used for the commercial processing of two bulks of Sussex and Kent apple juices at a newly-established factory at Kirdford, Sussex. As a direct result of these tests, in which the writers of this report collaborated, it was considered important to determine firstly, whether the heat treatment being used could be reduced in degree and duration, and, secondly, whether the efficiency of the pasteurization process was in any way prejudiced by the sterility of the vessels being filled from the pasteurizer outlet. The experiments to be described and discussed in the experimental section of this Report were intended to throw some light on these points.

* Some results obtained during 1939 are included in this paper for the sake of completeness.

EXPERIMENTAL.

The method of pasteurization to which the term "flash" has been applied, involves the heating of the juice at a relatively high temperature (185° — 195° F) for a comparatively short period of about 30 seconds. This process has developed from the earlier method in which the lower temperature of 145° — 165° F was associated with a heating period of 20—30 minutes. It was found that the cooked taste acquired by the juices as a result of the heat treatment was minimized by the adoption of the "flash" method and this has been recently introduced into many industries dealing with liquid products. It is obvious, however, that when such high temperatures as 185° — 195° F are being used, the juices should be cooled as soon as possible after the 30 seconds holding period, and, moreover, cooled down as far as is commensurate with the stability of the bottled or canned products. The degree to which the juice can safely be cooled will depend on the sterility of the bottle or can into which it is being filled, for an unsterile surface will depend for its sterilization on the residual heat left in the pasteurized juice. It will thus be appreciated that whilst it is desirable to cool the juice as quickly and as far as possible from the holding temperature, this procedure is limited in its application by the need to retain in the juice sufficient heat to complete the sterilization of the containers.

In order that these points could be examined as far as possible in a comparative way, the following scheme of experiments was drawn up to include the above considerations:—

Juice Extraction.

In view of the difficulty of combining the cider and unfermented apple juice programmes in the period of cider fermentation before Christmas it was decided to process the apple juices in January 1939. The fruit used for the tests was composed of the following sorts:—

- (a) 15 cwt. mixed culinary and dessert culls from Long Ashton plantations. This fruit was stored at 1°C and was sorted as occasion demanded and the rots discarded.
- (b) 10 cwt. third grade Essex culinary fruit in fair condition.
- (c) 8 cwt. Dabinett cider fruit of low acidity and medium astringency, stored at 1°C from November 1938—January 1939.

The condition of the fruit when milled was not as satisfactory as

could be desired, but all badly rotted fruit as well as specimens showing signs of considerable mould growth were discarded.

The fruit was milled and pressed without much difficulty. Maceration was carried out in a 600-gallon, open, slate tank, the disintegrated press-cake being suspended in the juice by means of a press-cloth shaped like a bag. The quantity used was 35 lbs. per 100 gallons of juice. The enzyme (0.1%) was added 12 hours before the macerate was removed. The total times for these processes were :—

Maceration	..	30 hours.
Enzyme action	..	56 hours.

The juice was centrifuged and filtered to a brilliant condition through a pulp filter and received into clean 100-gallon casks.

Processing Details.

Cold Method.

The brilliant, pulp-filtered juice was passed through a Seitz E.K. filter contained in a simple form of sterile bottling room which had previously been sterilized with steam. The equipment was steamed outside the room in the normal way and was put into position in the sterile room previous to its steaming. The bottles were soaked in a hot detergent solution, washed and rinsed and finally put over the Seitz wheel containing 2% SO_2 solution. The wheel was placed outside the sterile room and the rinsed bottles gained access to the room by means of a turntable.

Inside the bottling room the bottles were placed on the Satrap machine, which removed the SO_2 by means of a jet of sterile water, and were immediately filled direct from the E.K. filter and corked with closures that had been soaked in 2% SO_2 for 12 hours. The corked bottles were passed out of the room through an opening suitably protected with a rubber sheet. A photograph of this room is shown opposite page 235 of this Report.

Pasteurization in Bottle.

The juice was filled into ordinary bottles which had been given the normal detergent washing and rinsing treatment. Crown cork closures were used. The bottles were immersed in water at 90°F. The temperature was raised further by steam and maintained at the required level for $\frac{1}{2}$ hour. The bottles were shaken from time to time, and the temperatures related to the actual heat of the

juice and not to that of the surrounding water. At the end of the heating period the bottles were lifted out of the hot water and allowed to cool naturally.

Deaeration and Flash Pasteurization.

The general scheme of the deaeration and flash pasteurizing apparatus, as used during the experiments, is shown in the diagrammatic sketch in Fig. I, which illustrates the sequence of events in the final stage of processing prior to bottling. Reference to Fig. II will assist in explaining various practical features omitted from the diagram for simplicity.

The enzymed juice in the tank A is sucked by vacuum, produced by the vacuum pump V, through the inlet tube B and jet C into the deaerator tank D. Here, any air dissolved in the juice expands greatly due to the prevailing small vapour pressure and collects into bubbles which burst whilst the juice is flowing in thin layers over the removable cone-plates E, which are mounted on a small stand F. Removal of juice from the deaerator tank is effected by an extraction pump G, which delivers either to the heat exchanger for flash pasteurization or, if preliminary deaeration is performed, to the tank K.

All parts of the deaerator are made of suitable stainless steel, as are those parts of the heat exchanger in contact with the juice.

The heat exchanger L is designed to heat the juice as rapidly as possible to a flash pasteurization temperature of 155°—185°F, to hold it at that temperature for a 30-second period and immediately afterwards to cool to whatever bottling temperature may be required. The heating water circulation system is warmed by steam supplied through an injector nozzle R controlled by the steam cock P. Regulation of the cooling water flow is by adjustment of the valve Q. Thermometers, indicated in the diagram by T₁, T₂, etc., are placed at necessary points.

Construction of the heat exchanger is indicated in Fig. II which shows the machine in the "open" position, as it would occasionally be for cleaning. Basically, a number of thin, heat-exchanger plates S are rigidly clamped together. Juice is passed on one side of these and on the other side heating water or cooling water, as the case may be, flows in a direction opposite to the juice movement.

The required number of such plates are movably mounted on two horizontal cantilever-type bars, rigidly fixed to a supporting pedestal at one end.

Each plate has special features for rapid heat transfer and a system of inlet and outlet ports entirely obviate intermediate pipe connections. Liquid main entries and main outlets are all arranged either in the pedestal or in the clamping plate.

By operation of the three-way cock M, it was possible to pass water through the juice passages of the equipment. This was done on starting up so that temperatures could be adjusted without undue loss of juice, and again on closing down for the day so that the plant could be left in a clean condition.

All the experiments were done on the same day, and the various alterations in holding and filling temperatures were made whilst juice was flowing through the machine. Filling was not recommenced until the new temperature conditions of the juice had become stable. The filled bottles were crown-corked and were inverted for $\frac{1}{2}$ minute, after which the bottles were swilled in hot water, and stacked horizontally in open wooden boxes, each holding 5 dozen 10 oz. white glass bottles. A certain number of tests were made to determine the rate of fall of temperature in various bottled experimental juices.

The filling was done by means of a simple glass contrivance fixed to the outlet of the pasteurizer. A glass tube of 1 in. diameter was fitted with 2 outlet tubes of $\frac{3}{8}$ in. diameter, from which the bottles were filled. The filling temperature was given by a thermometer placed adjacent to the filling tubes.

Treatment of Bottles.

The treatments of bottles for the cold processing and the pasteurization-in-bottle series of experiments have already been mentioned. But the various treatments for the flash pasteurization section of the work need somewhat fuller explanation. It has already been explained that it was desired to elucidate the effect of the sterility of the container on the stability of the juices. Previous experience suggested that bottles washed in the normal way were by no means sterile and in consequence of this it was decided to use bottles "sterilized" in four different ways in each of the different pasteurization series.

All the bottles in the experiments were subjected to a preliminary soaking, brushing and rinsing. This process was carried out in a modern bottle washing installation, using a caustic soda detergent of 1% strength at 150°F for 20 minutes. The drained bottles were brushed internally and externally and finally rinsed

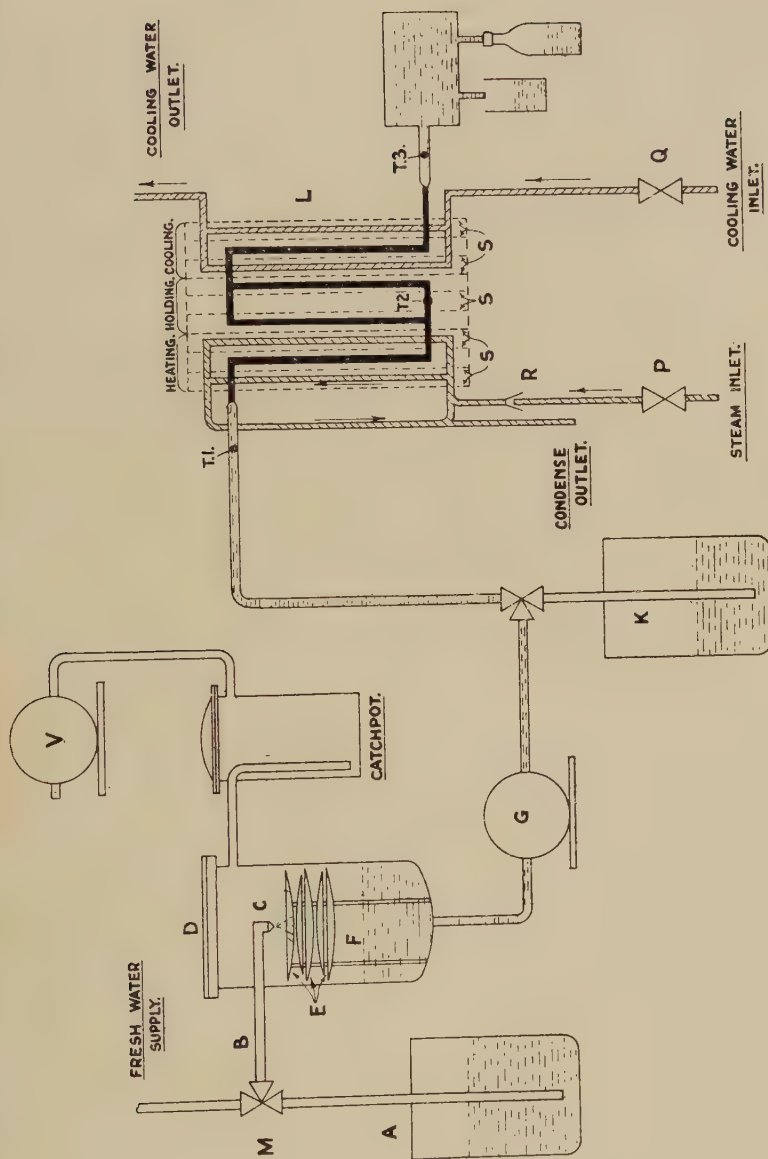


FIG. 1.

Diagram of Deaerating and Flash Pasteurizing Plant for Apple Juice.

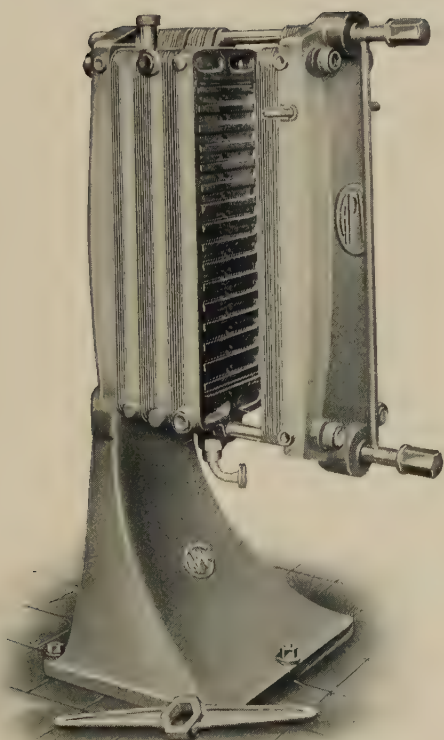


FIG. II.

Flash Pasteurizer in "Open" Position.

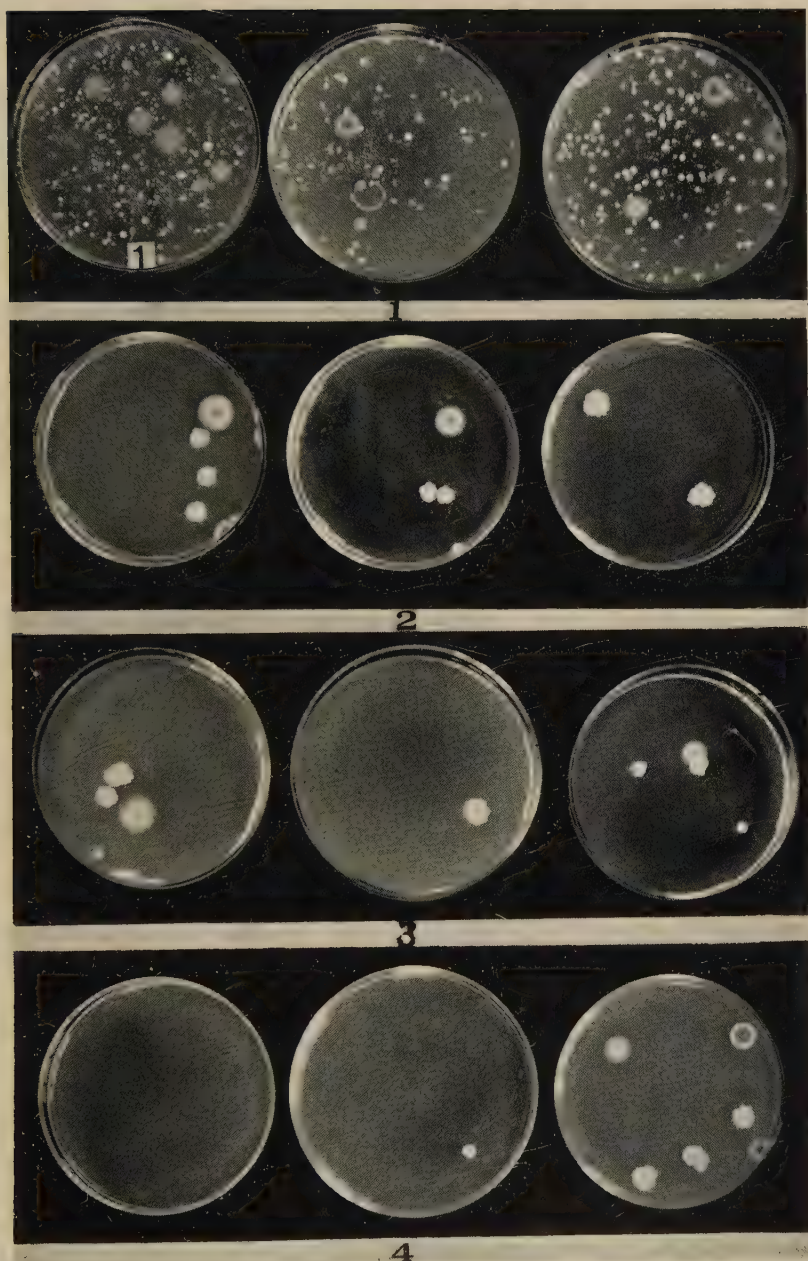


FIG. III.

Plate Cultures of Organisms from Bottles treated in various ways for Sterilization.

with clean water. These bottles were then prepared for the experiments as follows :—

- (i) *No treatment.* The washed and rinsed cold bottles were filled direct with hot juice. About 1% of the bottles cracked under these conditions.
- (ii) *Steamed bottles.* The clean bottles were passed slowly through a wooden chest into which live steam was continuously passed. The bottles were generally exposed to the steam for 20 minutes and emerged at a temperature of 120°—150°F. It was intended to maintain the bottles at the higher temperature, but in many cases the temperature of bottles in the inside of the cases did not exceed 120°F. This difference in the variation in stability of the juices filled into steamed bottles in some of the experiments. The temperature of 150°F. was not too hot for satisfactory handling of the bottles and no loss due to cracking was experienced. It was found as a result of experience that the most satisfactory means of even heating was to stack the bottles vertically in the cases, with the necks upwards and open to the steam.
- (iii) *Sterilized, drained bottles.* The cold rinsed bottles were sterilized with 2% SO_2 solution by means of the Seitz wheel. The bottles were then drained with necks downwards for 1 minute previous to being filled with the hot juice. The bottles smelt very strongly of SO_2 immediately prior to being filled.
- (iv) *Sterilized and rinsed bottles.* In this treatment the SO_2 from the Seitz wheel was not only drained but rinsed from the bottles by a high power jet of water sterilized by an E.K. filter attached to the Satrap rinsing machine. These bottles did not generally smelt of SO_2 although one or two were noticed in which a slight smelt was detectable. The bottles were filled in a cold condition with the hot juice immediately after they had been over the Satrap machine.

Sterility of Bottles.

The sterility of the four types of bottles used for filling in the flash pasteurization experiments was determined by precise micro-

biological methods. A surprising variation occurred between bottles in any one treatment in all the four series, thus causing difficulty in giving any precise statement as to sterility. The following points can, however, be made :—

- (i) The washed, rinsed bottles were infected with very considerable but varying amounts of yeasts and moulds.
- (ii) The steamed bottles, though seldom completely sterile, contained only a very few yeasts and moulds.
- (iii) The bottles rinsed with 2% SO_2 and then allowed to drain for 1 minute were practically sterile.
- (iv) The bottles from which the SO_2 was removed by the Satrap machine were not so sterile as the preceding sample but were more similar to the steamed bottles.

Figure III illustrates the relative sterility of bottles treated in the above manner. The numbers 1, 2, 3, 4 in the photograph refer to treatments i, ii, iii and iv above.

RESULTS.

Table I includes the observations on stability and general flavour characters, but further points will be raised after consideration has been given to the two main features.

Stability of Juices.

Samples of bottled juices were immediately incubated at 25°C , but in view of the experimental error involved on account of the variation from bottle to bottle, the data given in Table I were obtained by an examination of the whole stock of bottled juices. In general 7 dozen bottles were filled for each experiment.

The experimental results show that absolute stability was difficult to obtain, except in the juices pasteurized in bottle. The cold process bottling was the most effective that has yet been carried out at Long Ashton, and this must be attributed to the provision of the special bottling room. The juices pasteurized in bottle were quite sound. In the flash pasteurization series, reference to Table I will show that filling juices in cold bottles was quite unsatisfactory except in the case of No. 4, where the highest temperature of 160°F . had exerted a considerable sterilizing effect on the juice.

TABLE I.
EFFECT OF VARIOUS METHODS OF PROCESSING ON STABILITY AND FLAVOUR OF APPLE JUICES.

No.	Method of Stabilization.	Flash Pasteurization Treatment.					Condition of bottled or canned juices after 4 months cellar storage at 50°F.	Flavour of sound juices after 4 months cellar storage at 50°F.
		Holding temperature for 30 seconds.	Temperature of juice for filling.	Juice filled into hot or cold vessels.	Treatment of bottles or cans after washing and previous to filling.	Sterility of vessels prior to filling.		
1	Cold sterile filtration.	—	—	—	—	—		
2	Pasteurization in bottle (145°F. for 30 minutes).	—	—	—	—	—		
3	Pasteurization in bottle (155°F. for 30 minutes).	—	—	—	—	—		
4	Flash pasteurization.	185°F.	160°F.	Cold bottles	No treatment.	Variable but considerable yeast infection.	95% sound. Rest variable deposit of yeasts.	Nos 4—7 inclusive were very similar in character, with the exception of a strong SO ₂ flavour in No. 6. Nos. 4, 5 and 7 were full-bodied, clean and of a generally attractive nature. A slight cooked taste was noticeable in all samples.
5	"	"	"	Hot "	Steamed at 150°F.	Very few yeasts and moulds.	Sound. Few bottles with very slight yeast.	As for No. 2, but slightly heavier in flavour.
6	"	"	"	Cold "	Rinsed with 2% SO ₂ and drained.	Practically sterile. Less infected than 5 or 7.	95% sound. Rest very slight yeast deposit.	
7	"	"	"	Cold "	Rinsed with 2% SO ₂ and finally with sterile water.	Same as 5.	Sound.	
8	"	185°F.	140°F.	Cold "	No treatment.	As for 4.	98% fermented.	Nos. 8—11 inclusive were almost identical in flavour. Comparable juices in the preceding group of four were almost indistinguishable from these in flavour and aroma. They possessed a slight cooked taste.
9	"	"	"	Hot "	Steamed at 150°F.	" 5.	98% sound. Rest very faint yeast deposit.	
10	"	"	"	Cold "	Rinsed with 2% SO ₂ and drained.	" 6.	All sound.	
11	"	"	"	Cold "	Rinsed with 2% SO ₂ and finally with sterile water.	" 7.	98% sound. Rest heavy yeast deposit.	

TABLE I (continued).
EFFECT OF VARIOUS METHODS OF PROCESSING ON STABILITY AND FLAVOUR OF APPLE JUICES.

No.	Method of Stabilization.	Flash Pasteurization Treatment.				Condition of bottled or canned juices after 4 months cellar storage at 50°F.	Flavour of sound juices after 4 months cellar storage at 50°F.
		Holding temperature for 30 secs.	Temperature of juice for filling.	Juice filled into hot or cold vessels.	Treatment of bottles or cans after washing and previous to filling.		
12	Flash pasteurisation.	185°F.	90°F.	Cold bottles	No treatment.	As for 4.	
13	"	"	"	Hot "	Steamed at 150°F.	" 5.	
14	"	"	"	Cold "	Rinsed with 2% SO ₂ and drained.	" 6.	
15	"	"	"	Cold "	Rinsed with 2% SO ₂ and finally with sterile water.	" 7.	
16	"	160°F.	160°F.	Cold "	No treatment.	" 4.	Sound bottles of Nos. 13-15 inclusive were very similar in taste. They were not generally so full-bodied as Nos. 4-11, but the cooked taste was not less apparent.
17	"	"	"	Hot "	Steamed at 150°F.	" 5.	
18	"	"	"	Cold "	Rinsed with 2% SO ₂ and drained.	" 6.	
19	"	"	"	Cold "	Rinsed with 2% SO ₂ and finally with sterile water.	" 7.	
20	"	155°F.	140°F.	Cold "	No treatment.	" 4.	Nos. 16-19 inclusive were identical in flavour, and somewhat similar to Nos. 8-11. The aroma was good.
21	"	"	"	Hot "	Steamed at 150°F.	" 5.	
22	"	"	"	Cold "	Rinsed with 2% SO ₂ and drained.	" 6.	
23	"	"	"	Cold "	Rinsed with 2% SO ₂ and finally with sterile water.	" 7.	Nos. 21-23 were clean and possessed fresh but somewhat thin flavour characters.
24	"	185°F.	140°F.	Cold cans	No treatment.	Practically sterile.	Slight suspicion of "off" taste; very similar to No. 9.
25	"	"	90°F.	Cold "	"	"	Sound cans of juice possessed very fresh attractive flavour
26	"	155°F.	140°F.	Cold "	"	"	Clean and fruity.

The steamed bottles were more satisfactory, but even in this series the juices filled at 140°F. and 90°F. were unstable. Nos. 17 and 21, which were associated with lower flash pasteurization temperatures, were, however, practically sterile.

The bottles rinsed with SO_2 and filled subsequent to a short drainage were the most stable series, but this was obviously a direct result of the surprisingly high amount of SO_2 which had become incorporated in the juice. The figures for the relevant samples are given below:—

TABLE II.

RESIDUAL SULPHUR DIOXIDE IN VARIOUS BOTTLED APPLE JUICES.

No. of Juice.	Treatment of Bottle.	SO_2 content of juice in parts per million.
5	Steamed bottles	0
6	Rinsed SO_2 and drained	108
7	" " and rinsed sterile water	1
9	Steamed bottles	0
10	Rinsed SO_2 and drained	90
11	" " and rinsed sterile water	1
13	Steamed bottles	0
14	Rinsed SO_2 and drained	72
15	" " and rinsed sterile water	4
17	Steamed bottles	0
18	Rinsed SO_2 and drained	94
19	" " and rinsed sterile water	0
21	Steamed bottles	0
22	Rinsed SO_2 and drained	44
23	" " and rinsed sterile water	14

The high figures for the series of drained bottles are to be explained by the speed of bottling precluding a sufficiently long drainage period for the bottles. In view of the fact that the legal maximum dose of SO_2 in apple juice is 70 parts per million the series under consideration cannot be regarded as having any practical significance.

The series of juices which were filled into bottles which were rinsed on the Satrap machine were not so stable as the series in which the SO_2 was merely drained from the bottles. This difference is most accentuated in the cases of Nos. 14 and 15:

Flavour of the Juices.

The difficulties associated with critical tasting of a considerable series of products, all made from one original juice and in which the differences in flavour are merely those due to the variations in processing, can only be appreciated by those who have been confronted by such a task. The failure of the palate to react to differences in flavour is reached after the consumption of only a few samples and in a long series different results may be obtained according to the precise order in which the samples are tasted. The writers have attempted to make an examination of the problems affecting such tasting occasions and have obtained very interesting data. These will not be introduced into this report but the results of two tasting panels will be briefly alluded to.

In the first place, 15 of the 26 juices were chosen, and these were completely re-numbered by a disinterested person. Consequently no one, including the writers, was aware of the treatment associated with each sample. 25 opinions were obtained, including those of experts on fruit juices, members of Staff and their wives, and workmen in the laboratory and cider factory. The samples chosen were Nos. 1, 2, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 24, 26. The first five places in order of preference were given to Nos. 9, 1, 3, 13, 2. It was significant that the juices tasted last in the series were almost unanimously rejected by the panel, and it was considered that 16 such samples were too many for a critical estimate to be made of their flavours. Consequently, the samples were reduced to 8 in number and these were tasted by a selection of the members of the previous panel. Those tasting the juices were asked to place in order the three most attractive juices in the series. The results are given in Table III.

The results show a very definite preference for the juices flash pasteurized at the highest temperatures, and to a lesser extent, for juices filled into bottle at the higher temperatures. Although the majority of the members of the panel were aware of the supposed disadvantages of a cooked taste in apple juices, the results in Table III suggest either that the processing at the higher temperatures did not result in an excessive cooked taste or, alternatively, that such a taste was not identified by the panel. Another possibility is that the panel preferred the three leading juices on account of their much fuller character, but that this character was not associated with the "apple pie" flavour that is encountered on some occasions in cider.

Although the results in Table III appear to show certain im-

TABLE III.
FLAVOUR TESTS ON EXPERIMENTAL APPLE JUICE.

No. of Juices.	Treatment.	Points Awarded by Individual Members of Flavour Panel. (1st, 3 pts.; 2nd, 2 pts.; 3rd, 1 pt.)										Total Points.	Result of Tasting.
		N.E.*	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.	E.	E.	
1	Cold process	-	-	-	3	-	1	-	-	-	1	5	Equal 5th
2	Pasteurized in bottle at 145°F. for 30 minutes ..	-	-	-	3	-	-	-	-	-	-	3	6th
5	Flash pasteurized at 185°F. Filled at 160°F. ..	2	-	3	-	3	3	1	-	2	3	17	2nd
9	Flash pasteurized at 185°F. Filled at 140°F. ..	3	3	2	1	-	1	3	-	3	1	19	1st
13	Flash pasteurized at 185°F. Filled at 90°F. ..	-	2	1	-	-	-	-	3	-	2	10	3rd
17	Flash pasteurized at 160°F. Filled at 160°F. ..	-	-	-	2	2	-	-	1	-	3	8	4th
21	Flash pasteurized at 155°F. Filled at 140°F. ..	-	-	2	-	-	-	2	-	1	-	5	Equal 5th
23	Flash pasteurized at 185°F. Canned at 140°F. ..	1	1	-	-	1	-	-	2	-	-	5	Equal 5th

* N.E. Non-expert taster.
E. Expert taster.

portant differences between the juices, it should be emphasized very strongly that the juices were not distinguished by any very fundamental differences. Most of the differences noticed by the panel were only of a comparable nature and certain deficiencies would probably have been completely overlooked if the other samples had not been available to afford a contrast.

For the juice under consideration it can be said that none of the various processing treatments used in the experiments which have given stable products have effected any significant deterioration in the flavour of the juice.

In an attempt to obtain the views of a large number of people on the respective merits of some of the apple juices in the series of experiments under consideration, five of the juices were offered for tasting to the visitors at the Long Ashton Annual Tasting Day function on May 4th, 1939. The juices were poured from their bottles or cans into glass demijohns and the only indications given to the public were the letters A—E affixed to the jars.

The following information was given to each visitor on stencilled forms :—

“ A large bulk of apple juice was treated in five different ways in January, 1939. Samples of the finished products are contained in the jars labelled A, B, C, D, E.

In order to assist the Research Staff in ascertaining whether certain flavour differences are detectable by the general public, visitors are invited to taste the five products and to state which of the juices are personally most preferred. 1st, 2nd and 3rd choices should be given.”

238 forms were filled in and the result of the voting is given in Table IV. Three points were awarded for each first choice, two for each second choice and one point for each third choice.

Once again the preference of the tasters for the hot process is clearly indicated. The absence of the psychological influence of tasting canned juice from the cans themselves has resulted in this juice being placed second in order of attractiveness, whilst the superiority of the flash pasteurized juices over a similar juice pasteurized in bottle is very marked.

Relative Cooling of the Bottled or Canned Juices.

Figure IV indicates the rate of loss of temperature in four experiments. It is probable that only in the case of the juices bottled at 160°F. into hot bottles is it likely that the virtual holding pasteurization in bottle which takes place after bottling occurs will affect the flavour to its detriment.

TABLE IV.
LARGE SCALE TASTING OF APPLE JUICES.

Identification Letter.	Experiment No. of Juice in Table I.	Treatment of Juice.	Points Awarded.	Result.
A	5	Flash pasteurized at 185°F: <i>bottled</i> at 160°F	448	1st
B	24	Flash pasteurized at 185°F: <i>canned</i> at 140°F	289	2nd
C	1	Cold process	200	Equal 4th
D	2 & 3 mixed.	Pasteurized in <i>bottle</i> at 150°F for $\frac{1}{2}$ hour	200	" "
E	17	Flash pasteurized at 160°F: <i>bottled</i> at 160°F	258	3rd

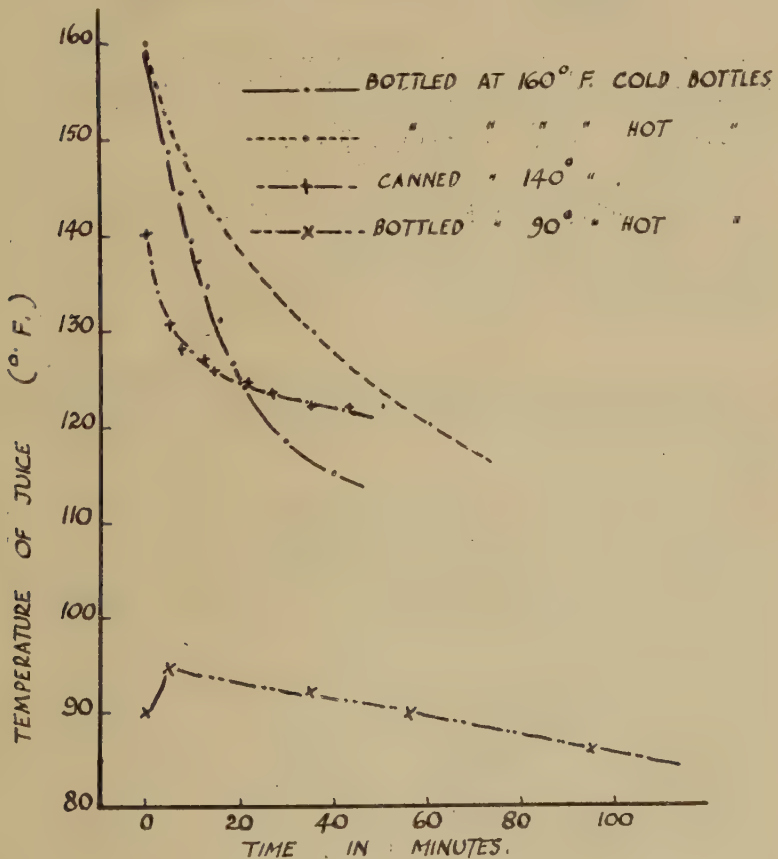


FIG. IV.
Rates of Cooling of Bottled and Canned Apple Juices.

SUMMARY.

1. A large bulk of apple juice produced from culinary (75%) and cider (25%) fruits was processed in 26 different ways, including cold sterilization, pasteurization in bottle, and flash pasteurization into bottles of varying sterilities treated as follows:—

- (i) Washed and rinsed bottles; (considerable and varying amounts of yeasts and moulds); filled cold.
- (ii) Washed and rinsed bottles, steamed to 120°—150°F.; (practically sterile); filled hot.
- (iii) Washed bottles, rinsed with 2% SO₂ and drained 1 minute (more sterile than ii or iv); filled cold.
- (iv) Washed and rinsed bottles, rinsed with 2% SO₂ and finally rinsed with sterile water (similar sterility to ii); filled cold.

2. Satisfactory sterility of the bottled product was obtained in 98% of bottles filled by the cold process, 100% of bottles in which the juice had been pasteurized in the container, and in varying percentages of the flash pasteurized juices.

3. Pasteurization at 185°F. for 30 seconds followed by immediate cooling and filling at 160°F. into hot steamed bottles gave a satisfactory product, but the sterility of the other products was affected to a considerable extent by the flash pasteurization and filling temperatures and by the sterility of the bottles into which the juice was filled.

4. The flavours of juices pasteurized at the highest temperatures were preferred by a flavour panel both to those of juices pasteurized at lower temperatures or in bottle, and also to the cold processed juice.

5. Five of the juices tasted by 238 visitors to the Long Ashton Tasting Day were placed in the following order (the figures in brackets being the number of points awarded).

- A. (448) Flash pasteurized at 185°F: filled into bottles at 160°F.
- B. (289) Flash pasteurized at 185°F: filled into cans at 140°F.
- E. (258) Flash pasteurized at 160°F: filled into bottles at 160°F.
- D. (200) Cold process.
- C. (200) Pasteurized in bottle at 150°F for $\frac{1}{2}$ hour.

Acknowledgments.

The writers wish to express their thanks to the Aluminium Plant & Vessel Co., both for the use of the deaerator and flash pasteurizer and for the loan of blocks for Figures I and II, and to Mr. G. P. Ogilvie of that firm for considerable help throughout the tests. They also wish to thank Dr. Hugh Dickson of the Fruit Products Section for assistance with the microbiological work.

REFERENCE.

- (1) CHARLEY, VERNON L. S. Investigation on Fruit Products. XIV. Experiments on the Production of Unfermented Apple Juice, 1934-38. *Ann. Report, Long Ashton Res. Stn.*, p. 195, 1937.

IMPRESSIONS OF THE GERMAN APPLE JUICE INDUSTRY.

By VERNON L. S. CHARLEY.

As a result of a Travelling Fellowship awarded by the Ministry of Agriculture in August 1938 the writer was able to attend the 12th International Horticultural Congress in Berlin and to visit the various centres of the German apple juice industry during that month. The following impressions were gained during the Conference and the later visits to factories in various parts of the country :—

Recent Developments.

The chief impression gained during the investigations was one of amazement at the remarkably rapid growth of the German apple juice industry. The figures given by Dr. Polzer indicate this phase of the commercial expansion.

1935	..	..	..	8	million gallons.
1936	..	..	..	5.3	„ „
1937	..	..	..	13	„ „
1938	..	..	..	17	„ „

There appears at present to be no limiting factor to the upward trend of the consumption of apple juice other than the supply of apples. The normal crop of fruit affords a quantity suitable for processing only approximately equal to the demand, and in years of short crops it becomes necessary to purchase supplies from surrounding countries. The quantity of fruit represented by 15 million gallons of juice is about 100,000 tons, and in short years the procuring of such a tonnage of apples represents a very difficult problem. For example, in August 1938, arrangements had already been made for the purchase of several thousand tons of apples from various Balkan countries.

The avidity with which the greater part of the juice is consumed disposes of many marketing difficulties which are associated with the present English industry. Quality is not of so great importance in the German juices. The health and athletic associations and

national organizations, often directly under the control of the Government, advocate in most definite terms the daily use of apple juices as health beverages, and such is the response elicited from the general public that many brands of juice which were considered by the writer to be of inferior quality were finding a widespread sale.

Organization of the Industry.

The whole of the industry is virtually controlled by the "Obst- und Gemuse-Verwandlung Gessellschaft." (The Fruit and Vegetable Association.) This organization has absolute power over the various fruit and vegetable raw materials. It decides how much fruit shall be allotted to the fresh fruit market, how much shall be converted into jam, and, lastly, what proportion shall be processed into juices. Licences from the Association are needed before production can be commenced, and the purchase of fruit and the quantity to be processed is fixed and determined by the same authority. Factories are examined by an official Inspectorate and the retention of a licence depends on the factory premises being maintained in a suitable state of cleanliness and the fruit being processed by approved methods. The Association administer the necessary legislation for standardization and the analytical or statistical check on the quality of the juices. Functions of this organization, such as the imposition of standards and the dissemination of information relative to the health qualities of apple juice, will be discussed separately.

Standardization.

Dr. Polzer, one of the chief Executives of the Association, reiterated to the writer on several occasions the importance of the strict standardization of apple juice. He emphasized the need for rigid enforcement of such standards as are considered desirable, in order that the faith of the public in the quality of the product may not be lessened. Samples of various varieties of apples are taken from the chief growing districts and the expressed juices are chemically analysed for a few "key" constituents. In view of the fact that the regimentation of the industry is so efficient that the destination of each bulk of fruit is definitely known, it is possible to compare the analyses of the control juices with those of the commercial products from the factory concerned.

Three standards of fruit juices are in common use in Germany :—

(a) *Pure juice grades.* The designation of these juices "Apfelsaft" (apple juice), is protected. Such juices must be 100% pure,

contain no sweetening substances such as sugar or concentrates, and must be free from colouring material and preservatives. Very large quantities of this grade were being sold. Indeed, the majority of the German apple juices conform to this very pure definition.

(b) *Slightly diluted juice grade.* This product is known as "Schorle," and is usually sold in a slightly carbonated condition. The beverage must contain at least 66% pure juice, but sweetening is permitted. Despite their cheaper price, it was strange to find these products in very limited consumption, and whereas "Apfelsaft" was obtainable everywhere, only a few stockists could supply the "Schorle" type of product. Apparently consumers prefer to purchase straightforward pure apple juice and to break it down with soda water.

(c) *Mineral water grade.* In order to separate the two grades (b) and (c) by as large a difference in quality as is feasible, the lowest grade of juice is regulated by the fact that it may not contain *more than 33%* pure juice. This ensures that the taste of such products shall be in sharp distinction to higher grades. Such legislation, whereby the juice content of a product is purposely kept *below* a certain figure, introduces a somewhat novel feature in food laws, but it was thought to have already proved itself to be a valuable means of effecting a clear division between two grades of juice. The one or two drinks of this low juice content type which were tasted were not of any special merit and contained considerably less flavour than the "Schorle" beverages. The lemonade type of drink is nearly always highly carbonated.

Propaganda.

An interesting feature of the German industry is the absence of any extensive advertising for different brands of apple juice. This follows as a normal consequence of the remarkable natural demand for the drink, and the absence of any need for competitive advertising relieves the various firms of one very considerable expense.

The Association mentioned above is, however, responsible for a very efficient and thorough dissemination of information relating to those characters of the juice which are of special importance for the maintenance of a healthy physique. Booklets and single page pamphlets setting out in simple and yet arresting fashion the information available on this subject are widely distributed. It is a little difficult to elucidate the scientific background for some of these pamphlets which give a popular presentation of the facts

of health, for the writers, in their enthusiasm for fruit juices, attribute to them the capacity to cure or afford relief from an extremely wide range of diseases or ailments. However, there appears to be a nucleus of scientific medical workers, who are now attempting to obtain precise evidence of the exact clinical type which will be satisfactory for the medical profession. These data will make a definite appeal to doctors and health specialists. The writer was shown many booklets in which the simple facts regarding the ready availability of the fruit sugars were displayed for the benefit of athletes, and such information is followed by advice to consume certain quantities of juice per day. Such advice, given though it is in an informal way, probably has the authoritative ring of a command to many German people, and it is probable that these pamphlets constitute the largest sales agency in the whole industry.

Workers on the medical aspects of fruit juice consumption, such as Neusser and Von Noorden, have obtained sufficient scientific evidence to indicate that fruit juices can be of extreme importance in the treatment of numerous diseases and complaints. Such work would probably be of similar importance to the industry in England at its present stage of gradual development.

To sum up this section, the total money spent on all forms of advertisement or publicity is absurdly small. The product has sold itself by virtue of its quality and inherent health-giving characters.

Technical Processes.

The Fruit.

No evidence could be found pointing to the preference for any special varieties of apple for juice production. At Eden, in Berlin, and again at the Government Research Station at Geisenheim-am-Rhine, the variety "Gold Pearmain" was mentioned as being one of the best, but apparently only limited quantities are available. The fruit in general is more acid than the ordinary English dessert apple but less acid than the Bramley's Seedling as grown at Long Ashton (acidity 1.3%). Sharp varieties are preferred in order that the sugar of the juice may not impart too cloying a taste to the beverage. The fruit is generally low grade material, separated from better fruit under the direction of the Association and only such quantities as are permitted by the authorities can be milled.

Factories.

The factories in Germany were not on the very large scale of some of the English cider factories nor of the Swiss works. Very few factories, if any, exist in Germany with an output of more than 250,000 gallons per annum. Many factories are wine cellars which have been converted for the production of juices. Most premises consist of a square, open courtyard with buildings around and cellars beneath: these are purely family concerns in which practically the whole family are employed on the premises.

Milling and Pressing.

The German mills and presses appeared to be more advanced in design than the English types. Swivel beds for the press are in general use and avoid the necessity for the provision of rails and movable trolleys. Mills are of different designs from English ones, and the presses operate at two speeds according to whether the press is commencing or finishing its work. Very large units were seen of all the above types. An interesting type of press was examined in the laboratory of Dr. Mehltz (Berlin—Dahlem) in which the pressure was intermittently applied and released. By this means it was thought that a better yield of juice would be more economically obtained.

Preliminary Clarification of the Juice.

Practically the whole output of juice is sold in a brilliant condition, although the firms who make a strong point of selling "natural" apple juice do not clarify beyond the point which is obtainable by a centrifuge treatment. Such juices are apt to be somewhat unbalanced in composition, *i.e.* they are rather sharp and often the bottles show a considerable deposit of pectic materials, together with a somewhat unsightly mass of fine fruit tissue which has not been removed by the centrifuge.

The initial clarification for products destined to be sold in a clear condition is usually carried out by a gravitational filter in which the juice passes downwards through a sludge of asbestos pulp, or through the latest form of plate and frame filter, using diatomaceous earth as a filter aid. The latter method seemed to be regarded as the more effective. The enzyme treatment was seen in practically all factories where clear juices were being produced. The time allowed for action was about 8—16 hours, but in some cases the temperature

of the juice was slightly raised to expedite the removal of pectin. Although such a procedure would be open to grave suspicion with English cooking apple juices, on account of their liability to excessive fermentation, it was stated that trouble from this source was not encountered in Germany.

Stabilization and Storage.

Subsequent to the preliminary clarification treatment the processes vary according as to whether the juice is to be treated by the hot or cold method.

(i) *Hot process.* The juices are generally cleared by pulp filtration and pasteurized at a temperature of about 68° — 72° C into 1,000—2,000 gallon steel, glass-lined tanks, or alternatively into glass vessels holding about 6—7 gallons. In the former case the tanks are fitted with sterilizing filters on the air inlet cocks, and are cooled by running water. The glass demijohns are generally stacked in crates in tiers of five jars and are allowed to cool naturally. This obviously subjects the juice to an appreciable "holding" pasteurization in addition to the initial flash pasteurization treatment. The sealing of the jars is now efficiently done by the use of the Baumann rubber cap, which possesses the additional advantage of giving a visible indication of any access of air to the liquor in the jars.

The Baumann "bell" pasteurizer was seen in general use. The machine is very reasonably priced, and several large factories used a battery of units, each capable of 100 gallons per hour. At Geisenheim, the latest form of sheet pasteurizer, using the principle of heat exchange, was seen. A similar machine made by an English firm has now been successfully used at Long Ashton for apple juice.

(ii) *Cold process.* The juice which has been roughly clarified by asbestos or filter-aid is impregnated by the usual Seitz-Boehi method and stored in large 5,000 gallon tanks under 120 lbs. pressure of CO_2 . An interesting development in this process is the use of solid CO_2 to provide the necessary pressure. In view of the cheaper price of the solid material it is not necessary to recover the gas when a tank is opened, thus avoiding the provision of a special plant for re-compression. Provided the required pressure is maintained in the tank no fermentation is possible in the juice.

It was observed that this method of storage was also used in

factories where the ultimate stabilization of the product into bottles was effected by the hot process. The combination of the two methods may be significant. Storage in Boehi tanks appears to be the safest form of bulk storage and obviates one heat treatment, whilst the hot process avoids the necessity of many of the precautions which are essential if bottling by the cold process is carried out.

Final Filtration.

The stored juices, after being suitably blended, are filtered through any of the previously mentioned types of filter or through the Seitz Ariston filter fitted with clarifying discs. Absolute brilliance is required for the filtration process, but the preliminary removal of solid tissue, together with precipitated pectic compounds, relieves the final filtration of much of its duty.

Bottling.

(i) *Hot process.* Three large factories using the hot process were examined in every detail. Despite the generally accepted idea that the hot process was safe under normal conditions of factory routine, it was discovered that the ordinary flash pasteurization treatment was accompanied by a "holding" pasteurization of quite an appreciable nature. The juices were filled into bottles of the Hock and Moselle type at a temperature of about 70° C. The washed bottles, however, were previously warmed to a temperature of about 60° C in order that the glass should not lower the temperature of the juice to an excessive degree and thus minimize the effect of the hot juice in sterilizing the surface of the bottle. At Obererlenbach the filled bottles were put into crates, stacked in a corner and covered with sacks to retain the heat for a longer period. The scientific principle behind the process of flash pasteurization, *i.e.* the use of a high temperature for a short period of seconds followed by a rapid reduction of the temperature to avoid the cooked taste, was not exemplified in the working conditions of either factory. The pasteurizer was merely being used as a convenient means of heating the juice and no attempt was made to cool the juice down from the higher temperature.

(ii) *Cold process.* The cold process was in very wide use in Germany. Apparently it is not favoured by small makers on account of the elaborate precautions which are needed for its efficient operation. But several installations of a medium scale

were seen, and one particular factory at Oberwinter was most interesting. The crucial factor is the sterility of the bottling room. In this case, a large room with glass sides was prepared and contained the bottling and sealing plant together with a system of compressed air whereby the pressure in the room could be constantly maintained at a pressure of 1 atmosphere above that of the outside air. As a result of this, the only outlet from the room where the filled bottles pass through a narrow opening, is not a danger from the point of view of infection from the outside atmosphere, as a continual current of air passes from the interior of the room into the outside building. The air used for the maintenance of this excess pressure is sterilized by means of a Seitz air filter. The bottles are washed in the outside room and are fed into a steam steriliser, which opens into the sterile room. A temperature of 100°C for 20 minutes is considered necessary for absolute sterility. The bottles are filled and crown-corked within a glass cabinet and the closures sterilized by minute gas flames immediately previous to being fixed on to the necks of the bottles. The whole room is carefully steamed before use and the personnel is chosen with an eye to their "infinite capacity for taking pains" over the various details of achieving sterility in plant and product. The loss by fermentation in the juices bottled by this plant was said to be completely negligible.

Other factories had adapted various rooms for use with the Seitz filter; in some cases a strong SO_2 atmosphere was maintained in the room, and in one factory in Rhine-Hesse the atmosphere was so thick that the workmen were provided with goggles and simple forms of respirators.

It has been a principle of the cold process to sterilize bottles with 2% SO_2 solution and fill the bottles after a drainage of about 1 minute. This procedure is now being modified to include a machine for removing the residual SO_2 from the bottles immediately previous to being filled. The Satrap (Seitz) machine consists of a small Seitz filter attached to a special jet. Tap water is sterilized by the E.K. pads and is forced in a powerful jet into the bottle.

Flavour of Commercial Juices.

It is certain that the Germans have fully appreciated the importance of providing cold drinks, for apple juices are always served at a temperature of about 8°C . Under these conditions the cooked taste of the hot processed juice was not so apparent as would have been the case if the temperature had been higher, but

many juices in national distribution possessed cooked tastes that would probably prejudice their widespread acceptance in this country. Some of the finest products tasted, however, were juices processed entirely in the cold. The true, fresh fruit character was very prominent although the acidity was excessive to English palates. Dr. Polzer remarked that the male population showed a preference for the cold processed juices, presumably on account of their similarity in character to the German wines, whilst women and children preferred the hot processed drinks, because of their fuller and less brisk flavour.

Papers read at a Conference and Working Demonstration on "Pure Fruit Juices and Syrups," held at Long Ashton on Thursday, March 23rd, 1939.

I.—THE LONG ASHTON CONTRIBUTION TO THE DEVELOPMENT OF PURE FRUIT PRODUCTS.

By B. T. P. BARKER.

The present paper is intended to serve more as an introduction to the proceedings of this Conference than a detailed record of the various investigations carried out at this Research Station on the subject of Fruit Products, as its title might at first sight seem to imply. The name of Long Ashton has, however, become so closely linked with the subject—and perhaps especially with the more recent developments relating to Pure Fruit Juices and Syrups—that a preliminary statement as to the manner in which this association arose and ultimately led to the convening of this Conference may be useful as a starting point to the remainder of the programme to-day.

The National Fruit and Cider Institute established for Cider Research.

Had it not been for cider, the outstanding English fruit product in beverage form of the 19th century and earlier, this Station would not have come into existence as and when it did, and, indeed, might never have been established.

In the main entrance to the laboratory building of the Station there is fixed a tablet presented by the late Robert Neville Grenville, of Butleigh Court, Somerset. It records the fact that the researches on cider-making carried on at Butleigh by himself and the late

Mr. F. J. Lloyd on behalf of the Bath and West and Southern Counties Agricultural Society between the years 1893 and 1902 had been transferred to the National Fruit and Cider Institute on the establishment of the latter in 1903. During the later stages of their intermittent seasonal work at Butleigh under the limited facilities in the farm cider-house and little improvised laboratory adjoining, it became evident that the investigations required more continuous attention throughout the year than was possible under the circumstances. It was agreed by those concerned that the subject and the results thus far achieved justified further effort under conditions more appropriate. Such, it was felt, required the establishment of a permanent research station, located as centrally as possible for the cider industry of the West of England and more convenient of access than Butleigh. The vicinity of Bristol was the obvious district, especially since it possessed the added advantage of reasonable proximity to the University College of that City with its Departments of Chemistry, Botany and other associated sciences and their scientific staffs. It was recognised also that for financial reasons as well as the needs of the subject itself, a broader programme than "Cider-making Research" was inevitable. For example, the study of cider-apples—the different varieties, their orchard and vintage characters, and the appropriate methods of culture—followed as a natural corollary. Thus developed the idea of an Institute with sufficient land attached to allow the production side of the raw material to be investigated. It was a natural extension to widen the scope still further and include within the ambit of the proposed Station research on fruit culture in general. With this more comprehensive scheme the Board of Agriculture of that time was able to obtain the essential promises of annual grants-in-aid from most of the County Councils of the West of England as well as the Bath and West Society, to supplement the government grant.

The result was the establishment of the National Fruit and Cider Institute at Long Ashton in 1903. Its major aims and objects have been briefly indicated just now. When in due course the University College grew into the University of Bristol, and when about the same time the Development Fund was created by Parliament and made increased grants for research possible, the Institute became associated with the University officially in 1912, and the research centre at Long Ashton was constituted the headquarters of the Department of Agriculture and Horticulture.

Having come into existence through "cider" and having been continuously engaged with investigations associated with that fruit product and its raw material during the thirty-six years

which have passed since then, the Long Ashton Station might fairly claim a direct interest in fruit products as a subject and to have made some contribution to the "Fruit Products" industry development on that basis alone.

Extension of Research at Long Ashton to other Fruit Products.

Cider, however, is not the special concern of this Conference to-day. Fruit products research at the Station has covered a much wider field. The course of the programme in this subject and the nature of the products investigated have developed naturally by evolution and been determined largely by the "needs of the times." This has led through a series of phases to the group of products which come before you for consideration in various aspects to-day. The title for this paper was selected to enable me to endeavour to show how the issues which confront us now have gradually emerged, and why we have felt it desirable to call this Conference to "report progress" and consider the position in respect of this young Pure Fruit Juice and Syrup Industry in this country.

In the time available a detailed account of the successive stages in the development of our work on fruit products is out of the question; but a short summary of the more important may suffice for present purposes.

"Cider" was quite naturally the first subject for investigation at Long Ashton. Having the advantage of centuries of practical experience in England, France and other countries in the making of this fermented product of cider apples and the results of the ten years of experimental work at Butleigh as a preliminary to the Long Ashton cider researches, progress in the latter was relatively straightforward and by the time of the outbreak of the Great War it had been possible to get a fairly comprehensive view of the difficulties confronting the producers of a pure fruit beverage, both from the processing and technical sides and those aspects affecting the interests of the consumer. Synthetic aerated drinks entirely devoid of any apple juice basis were commonly sold in those days under the name of "Cider": and although it was possible to get official action taken to check this misnomer, it brought to the forefront the difficulty under the then existing law of preventing serious though less extreme cases. In other words the issue of protecting the genuine producer and the consumer, where fruit products were concerned, by the establishment of legal standards, official definitions, or other means, was foreshadowed as far back as the pre-war era.

By-products of the Cider Industry.

The history of industrial development has shown repeatedly that the exploitation of by-products of an industry becomes of primary importance to its financial success as competition grows keener. Hence, as the modern methods of cider-making began to shape themselves with the aid of applied science, increased attention on the part of the research worker had to be given to by-products of potential commercial value. At Long Ashton, even in the pre-war period of its existence, this question of by-products was constantly arising in one form or another, and research in this direction came to occupy an increasingly prominent part in the Station's activities. Such matters as the following may be named in passing :—The production of cider brandy and cider vinegar ; the utilization of pressed pomace, *i.e.*, the residues of the cider apples after the juice has been expressed ; the preservation of this easily decomposable material by drying or other means, to conserve its value, until required for further use ; alternative uses for cider apples, especially in years of glut crops, including the preparation of “ Non-alcoholic Cider.”

In relation to this Conference, the experiments on pressed pomace and alternative uses for cider apples are most nearly concerned. They proved to be very useful in preparing the way for the development of our methods of making of some of the forms of the products on view to-day. In looking back on the work on “ non-alcoholic cider ” it may be of interest to mention that one of the earliest problems on which this Station was asked to advise, in 1904, was a sample of this type of drink. It certainly is remarkable that the methods used by its maker corresponded in practically all essential details with those now adopted in our English apple juice production, due allowance being made, of course, for the lesser efficiency of the requisite machinery and other equipment available then.

War-time Experiments and their Consequences.

A new turn to the course of the work of the Station was given by the outbreak of the Great War in 1914. Within a very short time increased food production and the utilization of all crops of potential food value became urgent. In the case of horticultural produce a Conference was convened by the Ministry of Agriculture in the first month of the war to consider, among other matters the means by which crops not needed for immediate use in their fresh state could be preserved and held in reserve to be drawn upon as required. It

was decided to place the organization and management of a suitable scheme in the hands of a small Executive Committee, on which the Long Ashton Station was represented. Note was taken of the very material increase in reserve food supplies which could be obtained from private gardens and allotments, when suitably cropped and all produce preserved or converted into food products that could not be consumed in the home while fresh. This meant the development of simple methods of fruit and vegetable preservation and utilization suitable to carry out under domestic conditions.

From this beginning there developed two important schemes—at first associated, and ultimately separated in the post-war period—for which this Station has been largely responsible. I refer, firstly, to the Campden Research Station, now the recognised research centre for the commercial fruit and vegetable canning industry in this country, and so important a factor in the remarkable expansion of that industry during the past two decades.

The second scheme is that dealing with instruction and research on the Domestic Preservation of Fruit and Vegetables. Its headquarters are here at Long Ashton. On the instructional side its work is being organized in close association with the Women's Institute movement, and by means of lecture-demonstrations throughout the country large numbers of housewives have now learnt domestic methods of making a variety of wholesome and attractive fruit products.

Other Long Ashton activities relating to fruit preservation and products during the war period were concerned largely with the preparation of fruit pulp and syrup for the jam factories and call for no further reference here: but one product of a more specialized character, which originated at this Station, may be mentioned briefly. This was "Apple Orchard Jelly." It was prepared from the expressed and unfermented juice of cider apples by concentration of the clarified juice in a "film evaporator" until the sugar content of the concentrate reached the required figure to result in the "jelling" of the dense syrupy liquor on cooling. Through this pure fruit product many hundreds of tons of cider apples became available in a form usable as a food, which otherwise would have been converted into cider.

Post-war Conditions and the "Cull Fruit" Problem.

With the end of the war the emergency researches and associated schemes mostly lapsed in their then-existing form, but in many

directions conditions had changed so drastically since 1914 that Long Ashton, in common with most other research stations, had not so much to revise its pre-war programme at the point at which it was broken off as to reconstruct one more in accordance with the new problems of the changed times.

One of the major issues which quickly developed for the English commercial fruit grower was the improvement of the quality of fruit sent to the markets for dessert and culinary use. It was his only chance of competing with overseas imported material. That led to higher standards of grading and packing, and an outlet had to be found for fruit below those grades. For apples the position was made more difficult because the jam manufacturers' no longer required them to the same extent as formerly. Conversion into cider was the obvious and simplest solution, and this line of utilization eased the situation for the time being. But with the large expansion of commercial apple growing in Great Britain the cider industry could not keep pace in absorbing the increasing quantities of apples of this type and fresh outlets had to be sought.

It has been a natural extension of the earlier work at Long Ashton to examine various possible alternative products and to associate with that section of its work a wider field of investigation embracing the corresponding problems for other kinds of fruit.

Fortunately, probably, for the progress of this branch of our work, the Research Station some years ago acted on the suggestion of one of its cider-making supporters that it should organize a tour for a group of cider-makers and others interested in associated subjects through some of the cider and wine making districts on the Continent. It proved so informative and useful for those making the trip, that other similar tours were arranged in subsequent years. Among the countries visited were France, Switzerland and Germany. It was on one of these tours, after seeing the remarkable development of the pure fruit juice industry on the Continent, that a conversation between some of the members of the party led to the establishment of the first "pure fruit syrup" factory in Great Britain—that of Messrs. H. W. Carter & Co., Ltd., at Ashton Gate, Bristol.

This factory placed every possible facility at the disposal of Mr. Charley and his co-workers in the Fruit Products Section of this Station. It enabled them to carry out a series of trials and experiments under commercial-scale conditions, which have furnished us with invaluable experience in the problems of factory-scale production.

Other conjoint investigations on "Fruit Juices" and "Un-fermented Apple Juice" in particular have been conducted at the Research Station with members of the technical staff of the Metal Box Company. To this Company also, as well as to the Aluminium Plant Vessel Company the Station is indebted for the provision of equipment for this and other associated recent work.

Important Questions for Consideration.

I am leaving Mr. Charley to deal with the more recent developments of our work at Long Ashton and elsewhere ; and will conclude with a brief reference to problems of another sort connected with these newer Pure Fruit Products.

Mr. Charley and others to-day will refer to such evidence as is available in respect of their nutritional and dietetic value. They will also place before you information indicating that some of them may possess qualities rendering them important from a therapeutic point of view. On such matters those interested in this industry must look to the medical profession for guidance in assessing the significance of the information so far available, and for the necessary further investigations required to confirm or disprove the claims which have been made by others. This Station certainly is not qualified to give a verdict.

At the same time, if these juices and syrups have even a fraction of the virtues some have claimed for them, it is important that the consumer should be certain of getting the "real thing." How this can best be ensured is a matter for serious consideration by all interests concerned, and Mr. Norbury's paper at this afternoon's session may indicate : for the future course of the industry will be determined by the nature of the decision.

II.—WORLD DEVELOPMENTS IN FRUIT JUICE PRODUCTION AND THE PRESENT ENGLISH INDUSTRY.

By ROGER C. MOREL

(Secretary Apple Juice Producers' Association).

The title of this paper suggests a comprehensive review of world developments in the production of many kinds of fruit juices. It is our purpose to-day, however, to study the history of those varieties of fruit juices which can be produced in our own country from indigenous raw material. This consideration excludes products which have gained enormous popularity in the United States of America and other countries where plentiful supplies of the respective raw materials are available, such as the juices prepared from oranges, grapefruit, pineapples, grapes and tomatoes. We are virtually limited, therefore, to a brief survey of the developments that have taken place in the production of unfermented Apple Juice and in the preparation of fruit syrups from the juice of our soft fruits, such as the strawberry, the raspberry, the loganberry and last, but not least, the black currant.

In the display arranged for your inspection here to-day you will observe that both these products—Apple Juice and Fruit Syrups—are now being prepared in this country on a commercial scale. They are, however, of quite recent introduction and it is necessary to go abroad in order to obtain an account of their origin and development, at least as far as Apple Juice is concerned.

Developments on the Continent.

Undoubtedly the preservation of unfermented fruit juices had its inception in the home kitchen.

Just as the manufacture of jams and preserves and the canning of fruit and vegetables have been developed to augment and to replace the home-produced article, so has the present-day commercial production of fruit juices sprung from a similar origin in order to provide for a similar need. There is evidence that for many years

past the housewife on the Continent has been in the habit of bottling a supply of fresh fruit juice for family use. It is possible that this custom has instinctively followed a sound dietetic principle important in countries where a comparatively hard winter cuts off the supply of fresh vegetables for many months.

Dr. Mehrlitz, author of the standard German text-book on fruit juice production, says that scientific investigations made as early as 1810 assisted home production, but that until the end of the century the medicinal rather than the nutritional value of fruit juice received first consideration.

Even to-day when large supplies of commercially-prepared Apple Juice are available in Germany, you will find up-to-date equipment on sale for the preservation of fruit juices in the home.

How important this domestic factor is I do not know, but it helps to explain the rather wide acceptance of fruit juices by the populations of Germany and Switzerland.

In both these countries there is a large number of small, old-established factories and farmer-producers, but it is not necessary to look back over many years to find the modern industry in its pioneering stage. The technical difficulties of large-scale production have indeed only been overcome during the past decade.

Switzerland.

It is appropriate here I think to mention a visit to Swiss factories of a party of British Cider-Makers under the guidance of Long Ashton Research Station in 1931. In that year we found that Apple Juice was being prepared on quite a large scale (though only about one-third of the present output), but that the technique of stabilisation and processing had not been finally determined. On referring to Mr. Charley's report of that tour I find that we inspected five Apple Juice factories and saw that four different methods of production were being employed. Only one of these factories was fully equipped for the method which has since been very widely adopted.

Some of us who had gone to Switzerland on that occasion to see the cider factories returned to England with the impression that this new fruit juice development might eventually be of some consequence to us too. Any country with apples to spare, we thought, might find it desirable to take note of these technical achievements and this trend in public taste.

In Switzerland an important factor affecting the growth of the fruit juice industry was the Federal Monopoly in the production of alcohol imposed in January, 1932. Hitherto alcohol had been widely distilled in country districts from fruit and other raw material. The object of the new legislation and control was to regulate production and reduce the consumption of alcohol in the interests of National Health. These regulations have undoubtedly stimulated the production of non-alcoholic fruit drinks.

As an instance of the considerable development that has taken place one might mention the oldest Co-operative in Switzerland, founded in 1900 at Egnach on Lake Constance. In 1931 this Co-operative was building an entirely new branch for the production of Apple Juice, spending £16,000 on a factory equipped to produce 110,000 gallons. This factory to-day has a storage capacity of more than double that quantity.

Another Co-operative visited in 1931 at Winterthur had a large cider output, but had put in a refrigerated cellar for a modest quantity of Apple Juice. I saw this factory again in 1936 and found that cider production had been entirely abandoned in favour of Apple Juice. The storage capacity at that time amounted to nearly a quarter of a million gallons.

Apple Juice Production Abroad at the Present Time.

Switzerland.

The position in Switzerland to-day can be summed up by giving the production figures. Approximately 5 million gallons of Apple Juice are now being made annually, this representing about 34,000 tons of fruit and a consumption of about 5 litres per head of the population.

Germany.

In Germany, the production of unfermented Apple Juice has reached much greater proportions, having grown from 2 million gallons in 1929 to 15 million gallons in 1937—a $7\frac{1}{2}$ fold increase in 8 years. Consumption, however, is about 1 litre per head of the population, or one-fifth that of Switzerland, and is now limited by the supplies of apples available. Fruit for juice production is strictly rationed. All factories are licensed and are subject to inspection and supervision by the State. The Central Association of German Horticulture is responsible for the general organisation of the industry and acts in an advisory and educational capacity.

Germany's contribution to technical knowledge and experience has been considerable, her outstanding achievement being the Seitz germ-proofing filter which alone makes possible the so-called "cold-process" now widely used in the production of Apple Juice.

Last August I had the opportunity of joining Mr. Charley on a visit to fruit juice factories in the Rhineland. A leading authority told us that there were over 2,000 plants of various sizes producing Apple Juice in Germany, the largest making from 100,000 to 250,000 gallons annually. The Rhineland and the middle of Germany were the most important areas of production. "Without propaganda, or advertisement as you know it," he said, "we are already drinking all the Apple Juice we can make." Owing to the fact that fruit supplies were not sufficient for juice production there was much variety in quality, but he stated that local preferences existed for one type of juice or another. For instance, in Saxony there has been a traditional manufacture of cloudy, unfiltered fruit wines, consequently a cloudy type of Apple Juice is preferred in that region, whereas in the Rhineland everyone is accustomed to a clear wine and a filtered Apple Juice is preferred. He stated that the production of Apple Juice had not affected the consumption of wines or beer.

Other European Countries.

As for the other European countries, there have been no developments comparable with those I have described, but it is to be noted that wherever apples are being grown there is some production of Apple Juice taking place. Czechoslovakia, Hungary, Poland, France, Holland, Denmark and Sweden all possess a fruit-juice industry in the pioneering stage.

U.S. A.

In the United States of America the production of unfermented Apple Juice is rapidly coming to the fore. For many years past it has been customary in that country for fruit-growers and cider-makers to sell large quantities of freshly-pressed Apple Juice during the autumn months. There had been little or no attempt to preserve this product—it was known as "sweet cider" and on sale at farms and roadside stalls as a seasonal attraction. During the past ten years other kinds of fruit juices have received a great deal of attention, principally from the canning industry. Output has increased from approximately $1\frac{1}{2}$ million cases (containing 2 dozen cans) in 1929 to 40 million cases in 1937. The State

Department of Agriculture comments on this development as follows :—

“ There has been a phenomenal growth in the consumption of fruit and tomato juices since 1929. Prior to that time grape juice and sweet apple cider were the only unfermented juices consumed in significant quantities. Since 1929, juices made from grapefruit, oranges, pineapples and other fruits have been packed commercially in large quantities. The increased production of juices is traceable to two factors—increased consumer demand for juice products, resulting largely from general appreciation of their convenience for use as breakfast fruits, dinner cocktails, and in mixed alcoholic drinks ; and increased supplies of fruits resulting in increased diversion of fruit from the fresh market to by-product use.”

Three years ago the industry in America turned its attention to the processing of unfermented Apple Juice by modern technique of the kind that has proved successful in Europe, and production is now more than 7 million gallons. It may be of interest to note that this figure represents an amount of juice equivalent to nearly two-thirds of the quantity of apples normally exported from the U.S.A. to Great Britain.

Writing last month of the future of the Apple Juice industry in America the spokesman of the New York State Agricultural Experiment Station says :—

“ New methods of preserving Apple Juice are doing much to change a seasonal product of mediocre quality into a first-class juice available all the year round. The enamel-lined can has proved to be an excellent container for this and other juices. I prophesy that if the Apple Juice canners are careful of the quality of the product, Apple Juice will soon be as important a commodity as tomato juice.”

In Canada, Australia and New Zealand the production of Apple Juice on similar lines to those described has already been started, the need for a satisfactory outlet for surplus fruits being perhaps the primary consideration.

The Industry in England.

We have now made a brief survey of developments abroad and return to this country to complete the picture. Before we finish we must take note of the development in England of another form of fruit product—the syrups prepared from the juices of our soft

fruits. This Research Station had examined these possibilities from 1934 onwards, and by 1936 had perfected the Long Ashton cold-process for their preparation. A Bristol firm has earned the distinction of equipping the first factory of its kind in the world for large-scale production by this process. These products are pure fruit syrups prepared from strawberry, black currant and other soft-fruit juices. They are sold in two forms—for mixing with milk or water as fruit drinks and for general cooking purposes, including the flavouring of ice-cream.

As for the production of unfermented Apple Juice in England, the industry is as yet in the early stages of development, only two years having elapsed since the installation of the first commercial plant in Devonshire in the autumn of 1936. This installation was followed by the establishment of a larger unit in Cambridgeshire in 1937 and in the past two years there have been other smaller-scale operations in Sussex, Kent and Worcestershire, chiefly by groups of fruit-growers interested in the utilisation of their surplus fruit and experimenting with their own raw material to this end.

An Association of Producers has been formed with the object of promoting the development of the industry along the lines of a genuine unadulterated Apple Juice with a definite specification and standard of production.

Conclusion.

The world developments which I have described show, I think, that three main influences have encouraged the rapid growth of the fruit-juice industry during the past ten years. These are, first, the availability of plentiful supplies of fruit for by-product use; secondly, the advance in technical knowledge and skill, and thirdly, the growing appreciation of fruit products by the consumer as a result of his increasing knowledge of their intrinsic value as a factor contributing to health.

III.—FRUIT JUICE STANDARDISATION.

By CHRISTOPHER P. NORBURY,

Sherridge, Malvern.

The Need for Food Standards.

During the past few years much has been said and written on the subject of "The Nutrition of the People." The findings of Sir John Orr and other workers—that many of the population are living on a diet which is insufficient for bodily health—not only arouses resentment among those who are underfed, but also among the producers of primary commodities who in many years are unable to get a reasonable price for their produce. In the case of apples and plums in particular there are years when it does not pay to pick them. This has led to many enquiries on price and distribution, but such enquiries are of little value unless quality or grade is given consideration.

In the days when the produce was sold direct to the consumer, the need for food standards was not so apparent, but now practically everything which the producer sells goes through the hands of a middleman. The middleman—or rather middlemen—have to make a living, and it is not unnatural that they should but their goods in the cheapest market and sell in the most expensive: here you see the need for food standards which will enable the buyer and the seller to effect sales on the basis of a given quality or grade.

Up till recently no food laws were contravened, provided the food which the purchaser bought did not endanger health and that the food was of the nature and substance and quality demanded.

The difficulty arises when we come to ask "what is the nature, substance and quality of such articles as Strawberry Jam, Honey, Ice Cream, Sausages, Beer, Cider, Wine, or, in particular. Unfermented Apple Juice or Fruit Syrups?"

Taking Strawberry Jam for instance—you may see on the pot "Full Fruit Standard" which is a voluntary standard agreed to by the Food Manufacturers' Association: but if the words Full Fruit Standard are omitted, there is no-one to judge, and certainly

the ordinary member of the public cannot tell the proportion of strawberries in the jam. The general public also cannot tell whether fruit in jam has been preserved in sulphurous acid first, or whether it has been made from fresh fruit. Similarly in the case of Ice Cream, how can one tell whether the ice cream is genuine, or whether it is a frozen concoction of cornflower, lard, colouring matter and a little fruit essence?

We might also enquire before taking our next dose of fruit salts, if we have not been able to stand the strain of these synthetic foods, from what fruit do they originate?

The newspapers and periodicals are filled with patent medicine advertisements, and it is surely alarming that during last October—our chief month for apple production—the money spent on advertising apples was £71, while two large firms of laxative manufacturers spent over £10,000 between them.

Standards for Apple Juice.

Perhaps I may have spent rather too much time emphasising the need for Food Standards in general, but now I will turn to the need for a standard for Apple Juice in particular.

Last year a new Foods and Drugs Act was introduced and passed into law. Besides containing much of the material of the older acts, there are one or two additions.

The one which concerns us to-day is Section 8 where it gives power to the Minister of Health to regulate foodstuffs "Where there may be danger to health, or loss of nutritional value, or otherwise for protecting purchasers." It is under this section that those interested in the development of the Fruit Juice Industry hope that the Minister will take action.

At the present time there are beverages being sold under the name of Apple Juice which call for regulation to protect the purchaser, and if, as we hope, Unfermented Apple Juice is going to take its rightful place in the diet of the nation, it is of the utmost importance that the product be absolutely pure and healthy and standardised, and can in no way be confused with a synthetic juice. Unfermented apple juice is essentially true to name, but it is naturally more expensive than a coloured water with a little fruit essence added—a product so tempting for an unscrupulous manufacturer to prepare. In view of the possible importance of fruit juices for general health or other specific disorders, it is essential that the public should know when they purchase the pure, genuine fruit juice.

In Germany, where the industry has developed most markedly, standards have been adopted from the start, and the beverage has won the confidence of the people. It is easier getting standards adopted there, in fact they had a standard for beer before 1500, and this is no doubt the reason why German beer enjoys such a reputation to-day.

Rigid standards are adopted for Apple Juice in Switzerland too. In both of these countries the greater proportion of the Medical Profession back it up for its value in correcting various diseases and from a general health point of view ; but Mr. Charley will be dealing with the clinical aspects in his paper.

My main points are : Firstly, we do not wish to base our claims on the fictitious advertising of a product which exploits human credulity—as is so often the case with patent medicines—but on a standard article of known composition which is as near as possible to a natural product. Secondly, we want protection from competition from spurious juices.

The fruit juice industry in England is determined to get standards adopted. The National Farmers' Union has formed a sub-committee to draft actual definitions in co-operation with the industry to safeguard a flourishing fruit juice industry which promises a good outlet for fruit which is not up to the standard of market requirements. Quoting Germany again, in 1938, 30 per cent. of their apple crop was made into unfermented apple juice, which does emphasise the possibilities the industry offers to the fruit grower.

The views of the committee were that a grade of apple juice should be defined and suitably named to include only fresh, undiluted, apple juice, having undergone the minimum treatment necessary for clarification and stabilisation and to be free from colouring matter and preservatives.

It may be desirable to define a sweetened juice as well, and also a concentrate if one is made. In any case we feel that the consumer has a right to know what he is buying, especially as this is an article which can be fairly easily imitated.

Personally, I should like to see all beverages conform to defined standards, especially beer, cider, orange and lemon squashes, and crushes, and if the mineral water trade wish to sell so-called fruit drinks, the public have a right to know how much fruit they are getting ; and the fruit grower would be glad to supply them with fruit.

In this country we are fortunate in a way by being one of the

last countries to adopt standards for beverages, for we can draw upon the experience of other countries who have been working on standards for some time. I will take the case of Canada, and give some of the regulations adopted for certain fruit juices.

Canadian Regulations.

No. 1. Fruit juices shall be clean, unfermented, liquid products obtained by the first pressing of fresh fruit, and shall correspond in name to the fruits from which they have been obtained, and shall contain not more than 2 per cent. of alcohol by volume. (In Germany the maximum alcoholic content is 0.5 per cent.).

No. 2. Apple juice, whether the fresh juice or the dilution of a juice concentrate obtained from apple, the fruit of *Pyrus Malus*, shall have a specific gravity (at 20° C.) not less than 1.0415 nor greater than 1.0690, and shall contain in 100 ccs. (20° C.) not less than 6 grams, and not more than 20 grams of total sugars in terms of reducing sugars, not less than 24 centigrams nor more than 60 centigrams of apple ash which shall contain not less than 50 per cent. of potassium carbonate.

No. 3. Grape juice must be the juice obtained from Grapes (*Vitis* species), and shall have a specific gravity (at 20° C.) not less than 1.0400 and not exceeding 1.1240, and shall contain in 100 ccs. (at 20° C.) not less than 7 grams and not more than 28 grams of total sugars in terms of reducing sugars, not less than 20 centigrams and not more than 55 centigrams of grape ash, and not less than 15 milligrams nor more than 70 milligrams of phosphoric acid.

No. 4. Lemon Juice shall be the juice of lemons, the fruit of *Citrus limonum* Risso, shall have a specific gravity (at 20° C.) of not less than 1.030 and not greater than 1.040, and shall contain not less than 10 per cent. of solids, and not less than 7 per cent. of citric acid.

Other regulations refer to Lime and Orange juices, sterilised fruit juices, concentrated juices, sweet fruit juices and syrups.

In the case of German regulations, these are much more detailed and they define the permissible processes of pressing and filtration, cellar storage—in fact every detail of manufacture. Factories are inspected and the whole industry is regimented. We feel at present this is unnecessary if the results can be obtained by other means.

The use of preservatives in pure apple juice is strictly forbidden. I think incidentally that the present tolerance of preservatives in Orange and Lemon juices in England may be found to be too high and most certainly their presence should be declared on the label.

The effect of standards enables a series of products to be manufactured which really do contain a reasonable quantity of fruit juice. The specific gravity and ash content have to be defined to prevent spurious products from being put on the market. I was told the other day of a man who is trying to raise money to produce a new foodstuff which contained a good deal of water—his method was to whisper in the ears of likely investors “water is cheap !”

Now, many people say it is all very well having standards, but even when you have got them is it quite easy to make a cheaper synthetic article? Well, there are coiners and forgers who still think the same about money—but they are generally caught in the end, and I feel quite sure that there are analytical chemists who will have no difficulty in bringing culprits to book.

But should there be any difficulty, then we shall have to press for Government inspection of all food factories in the same way that the farmer has to undergo inspection of his premises where he is producing milk.

Having outlined the position, this is the course of action we are taking. Fruit growers and the fruit juice and syrup industry are preparing standards for apple juice which, with the support of the Ministry of Agriculture, we propose to present to the Minister of Health and ask him to make regulations. This is really our short term policy. Our long term policy is to have standards laid down for all beverages, and, personally I should like to see many other food commodities regulated as well.

It is really for consumers rather than producers to demand these standards, for it is they who are likely to gain most by better nutrition. Unfortunately there are no consumers' organisations in this country who can speak with one voice. But surely it is of advantage to all of us to see this industry founded on a really pure standardised product—and I do ask for the support and sympathy of the distributive trade, and the medical profession especially, for both will undoubtedly benefit.

We hear so much about National Fitness these days, but how can we have an A1 nation when a large part of it lives on C3 food? Under this new Foods and Drugs Act we have the opportunity of getting the Minister of Health to regulate this one commodity whose raw material is the most important fruit this country produces. I trust we shall not fail.

IV.—PURE FRUIT JUICES AND SYRUPS: THEIR METHODS OF MANUFACTURE, CHEMICAL COMPOSITION AND SIGNIFICANCE FROM NUTRITIONAL AND MEDICAL POINTS OF VIEW.

By VERNON L. S. CHARLEY, B.Sc.

(Fruit Products Section, University of Bristol Research Station,
Long Ashton).

Beverages with which are associated the names of various fruits, either of foreign or home origin, are very widely distributed in this country at the present time. Their nature and composition vary to a remarkable extent, and it is no part of the writer's intention to attempt to describe and discuss the complete range of such drinks. It has already been noted in the previous papers read at this Conference that a certain significant trend in fruit juice production is concerned with the development of two types of products, *i.e.* apple juice and fruit syrups, in which an attempt is being made to reduce the various processing manipulations to the absolute minimum and to place the greatest possible emphasis on the importance of purity and nutritional value of the product. Attention will consequently be paid merely to these two types of beverage in this communication.

Important Characters of Fruit Beverages.

It must be obvious that for juices to achieve a ready sale they must possess certain features which will attract the attention and retain the satisfaction of the public. Prominent amongst these characters and probably of chief importance are the four following points :—

- (a) Attractive fruit flavour.
- (b) Correct balance of sweetness and acidity.
- (c) Attractive colour and brilliant appearance.
- (d) Nutritive value.

It is a regrettable feature of the average mentality of the man in the street that the nutritive value of a fruit juice has only recently possessed any significance whatever and it is still probably the least important factor from the public's point of view. It is similarly to be deplored that brilliancy of appearance has for so long been one of the chief factors influencing the sale of beverages, and only since the introduction of the cloudy fruit crushes or squashes, has it been considered to be of less importance.

In considering a processing technique for pure fruit juices and syrups, attention must be paid to the four points enumerated above. Brief consideration will be given to each in turn.

(a) Fruit Flavour.

The characteristic flavours of the various English-grown fruits are due to the presence in the juice of a mixture of esters, ethers, acetals, etc., which, by virtue of the precise nature of the blend, provides the specific flavour of the fruit. That the flavouring compounds are volatile is obvious to anyone who has walked near a heap of apples or through a plantation of black currants. But mere loss of intensity is not the only change that can affect fruit flavour. Just as citrus juices can develop "stale," musty and rancid flavours due largely to chemical changes, so also, in English fruit juices, the various compounds from which are derived the organoleptic qualities of the juice can undergo certain changes which effect more or less complete alterations in the flavour of the product. Under certain conditions strawberry juice can completely lose its identity in three months, when it could be mistaken for a rather thin, freshly expressed Spanish grape juice. The chemical changes are difficult to control and to determine with any exactitude, but oxidase action is liable to effect considerable changes in taste, and oxidase action is liable to effect considerable changes in the flavouring substances. This biochemical action is minimized by the deaeration of the juice and the inactivation of the oxidase systems by pasteurisation, and both these processes are now in commercial use.

(b) Sugar-acid Ratio.

Personal tastes differ very widely on the question of the sweetness or sharpness of fruit drinks. The average malic acid acidity acceptable in this country is in the neighbourhood of 0.5%, whilst in France the figure falls to 0.3%, but in Germany rises to 1.0%.

an acidity which would be quite unpalatable to the English public. The problem of adjustment is very largely connected with the raw material, which varies to a wide extent in respect to its acidity. Some cider apple juices possess acidities as low as 0.15%, whereas Bramley's Seedling cooking apple juice often contains above 1.0% of malic acid. The maintenance of a regular output of juices and syrups at a standard acidity and sweetness can be ensured only by carefully planned blending or by the addition of acid or sugar, or the removal of acid in the case of sharp juices. Whilst there is no real objection to be raised to the chemical adjustment of the sugar and acid contents in fruit juices, it is considered that blending should always be attempted in the first place, thus endeavouring to maintain the juice in a condition as near as possible to its original state.

(c) Attractive Colour and Brilliant Appearance.

These two features are complementary, for should any lack of clarity occur in a fruit juice, the colour is immediately affected, the intensity and brightness of the colour being impaired. The one important problem relevant to the subject of this communication is the removal of pectic substances. Both by chemical and enzymic action the pectic constituents of freshly expressed fruit juices are liable to undergo certain changes in composition which lead first to the formation of a cloudy appearance followed by the deposition of a flocculent material which is unsightly in a bottled product. This problem is an acute one in pure fruit beverages, where the original pectin content is appreciable; it has eventually been overcome by the use of commercial enzymes which have stabilized the pectic compounds within 48 hours of expressing the fruit. The achievement of clarity is now a matter of no difficulty for the enzyme action reduces the viscosity of the juices to such an extent that the de-pectinised juices are easily passed through a suitable type of filter.

(d) Nutritional Value.

In the case of apple juice, the nutritional elements have been considered to be the fruit sugars, and Vitamin C. The different processes involved in producing apple juice do not greatly affect these constituents, in fact the Vitamin C content of all apple juices so far examined at Long Ashton have been entirely negligible. But in the case of syrups, the retention of the very high contents of Vitamin C in the fruit juices is of the greatest importance and optimum conditions for retention have yet to be discovered.

It seems probable that important nutritive features of pure juices and syrups may be due to certain constituents which are as yet undetermined, and consequently it may prove to be a task of some difficulty to elucidate the precise effect of various types of processing on the nutritional value of the products.

With the above observations to serve as indications of the underlying conditions to which the final processes must conform, it will be convenient to proceed to a brief description of the actual methods of commercial manufacture of apple juices and syrups.

Apple Juice Processing.

The apples are washed (where necessary) and ground into a fine pulp by grater or hammer mills. The juice is expressed from the pulp by hydraulic pressure, the yield, in general, being from 150—170 gallons per ton. In some cases the juice is macerated for 12 hours with a portion of the residue remaining in the press cloths, to impart a certain fullness to the juice that is not a feature of the freshly expressed juice. The juice is next treated with an enzyme which is allowed to act at room temperature, or slightly above, for 12—48 hours. A remarkable clarification occurs, for the pectin removal and consequent decrease in viscosity of the juice permits a more or less complete deposition of finely divided tissues and precipitated materials.

The clarified juice can now be treated in a variety of ways. Amongst these may be mentioned the following:—

- Hot (i) Filtration and pasteurization into bottle or in bottle.
- „ (ii) Pasteurization followed by storage in glass jars or metal tanks.
- Cold (iii) Sterilizing filtration and storage in sterile wooden casks or bottles.
- „ (iv) Centrifugation and storage in 5,000 gallon steel tanks under pressure of 120 lbs. CO_2 /sq. inch.

Undoubtedly the last method is the most popular at the present time. The scientific principle, the discovery of Professor Boehi of Switzerland, involves the impregnation of eight atmospheres pressure of CO_2 into the enzymed juice. This physical method of storage is a sure safeguard against fermentation or microbiological activity. The cold process, which is in widespread use in Germany in commercial factories, consists of the use of these bulk storage



Photograph of working demonstration of sterile bottling of apple juice shown at the Fruit Juice Conference.

tanks in combination with the Seitz method of sterile bottling. The filter discs are capable of retaining yeasts and bacteria, and the secret of success in this process is to prevent the access to the sterile juice of organisms which would cause fermentation later in the history of the juice. Most elaborate precautions are taken to ensure 100% sterility in the bottled products. The bottling room is treated as a sanctuary, and the sterilization of the plant, bottles, closures, clothes of working personnel and the air in the room itself is given every attention. The pressure of air in the bottling room is maintained at one atmosphere above that of the outside air, to ensure a continual outward flow of air and prevent any access of yeast-infected air into the room.

The other process (hot method) involves the flash pasteurization of the juices into steel tanks lined with a resistant covering, or into 5—10 gallon glass jars which are subsequently fitted with patent rubber caps. After storage, the juices are re-filtered and pasteurized into bottles or cans for sale. The pasteurization process affects the flavour to some slight extent, but with modern improvements it is possible to avoid any unpleasant cooked taste in the juices and, in many cases, stable juices have been prepared in which the flavour has been practically as fresh and true to the fresh fruit taste as those produced by the cold process. Those juices which are made completely in the cold are characterized by very fresh, clean and attractive flavours, reminiscent of the fresh, raw juice and in many cases superior in quality to it. It is not clear, however, whether the general public will appreciate the fine points of difference in flavours. In some juices, such as Bramley's Seedling, it is probable that the more attractive juices will be made by the use of a carefully controlled flash pasteurization method, but with juices which are sufficiently flavoured, the cold process is unique in retaining the fresh flavour that is so attractive.

The final filling may be into bottles or cans. There are a number of advantages associated with the use of cans, and in the last two years special, tasteless wax linings have been developed which have proved to be satisfactory over a very long period of contact with apple juices. The can is a most hygienic container for fruit juices, and although a certain amount of prejudice still exists, there are signs that the advantages offered by this package are being more and more appreciated.

In Germany, and in very recent months in this country too, dispensing machines have been introduced for the convenience of hospitals, clinics, nursing homes, etc. The juices can be drawn off at any time, and a filter or valve in the neck of the 5—10 gallon vessel sterilizes the air which is drawn in.

Fruit Syrup Production.

The methods in this case vary fundamentally from those used for apple juice. In the case of English soft fruits, it is often impossible to obtain an economic yield of juice by direct expression of the juice from the milled fruit on account of its extremely viscous nature. Consequently, the fruit is smashed and the commercial enzyme (0.2%) is allowed to act on the pulped fruit itself. Temperatures are apt to be high during June and July when most of the processing is carried out, and spontaneous fermentation is an ever-present danger. Strawberries and raspberries are generally depectinized in 16—24 hours, whilst black currants take from 3—5 days. The effect of the enzyme is remarkable. A progressive thinning of the juice results in a solid, hard layer of tissue forming on the top of the vats, whilst the clear juice collects at the bottom. The juice is run off, the layer of tissue is pressed and the blend of the two bulks of juice is centrifuged, syrupe with pure solid cane sugar until the syrup registers 55% sugar by weight. The solution of sugar is carried out, as are all the other processes, in the cold. It has been found that with pure fruit syrups of this type, it is necessary to adjust the acidity to 1.0% citric acid by weight if it is desired to preserve the syrup by 350 parts per million of SO_2 . Consequently this adjustment is made (it is only necessary, in general, in the case of the strawberry) and the syrup is preserved with SO_2 , filtered and stored in bulk. Reference will be made later to the gradual inversion of the cane sugar, until approximately equal amounts of glucose and laevulose are present. The syrups are practically free from any pectic substances that are determined by the calcium pectate method, and this feature may be of some significance from the point of view of the health aspect of the use of black currant syrup.

Concentrates.

Concentrates possess many advantages over syrups from the storage point of view. In recent years great improvements have been made in the hot method of evaporation in vacuo, and it is now possible to fractionate the distillate and collect the volatile fractions with a view to their return later to the concentrate. But, despite these improvements, the fresh fruit character is impaired to some extent, especially in the case of the strawberry. Recent experiments with an English evaporator in a Bristol factory by the writer have shown the possibility of producing very attractive concentrates from raspberry juice, but strawberry was not so satisfactory.

TABLE I.
ANALYSES OF ENGLISH APPLE JUICES.

No.	Source.	Variety of Fruit.	Age of Juice.	Specific Gravity.	Acid %	Tannin * %	Nitrogen (Organic) %	Protein (N x6.25) %	Total Ash. %	Principal Ash Constituents % of Total Ash.					Fe ₂ O ₃	Calcium Phosphate %	Vitamin C mgm/100 cc.
										K ₂ O	Na ₂ O	Ca O	Mg O	P ₂ O ₅			
1	Long Ashton	Bramley's Seedling	1 year	1.049	0.92	0.13	0.0022	0.0137	0.223	50.12	2.39	6.46	3.39	7.79	2.76	0.0874	2.4
2	"	Kingston Black	3 months	1.057	0.53	0.17	0.0042	0.0262	0.329	44.45	2.63	6.67	5.94	7.60	1.89	Nil	1.9
3	Devon	Cider	1 year	1.047	0.62	0.17	0.0036	0.0225	0.240	46.51	1.99	5.31	4.75	7.16	2.08	0.0065	1.2
4	Sussex	Cooking & Dessert	"	1.063	1.01	0.13	0.0145	0.0906	0.495	31.26	1.01	15.10	3.15	5.19	0.84	Nil	1.5
5	Kent	Cooking	"	1.062	1.00	0.11	0.0108	0.0675	0.309	49.35	1.08	3.47	3.22	7.64	1.61	0.0159	1.5
6	Cambridge-shire	Cooking & Cider	"	1.046	0.71	0.12	0.0080	0.0500	0.346	53.78	0.65	4.34	1.70	4.91	2.04	Nil	0.9
7	Kent	Cooking	3 months	1.047	0.55	0.11	0.0103	0.0644	0.243	54.28	0.63	4.57	3.74	8.87	0.86	Nil	0.5
8	Long Ashton	Essex Cooking + 10% Cider	"	1.049	0.55	0.14	0.0130	0.0812	0.210	49.50	1.72	4.59	4.36	9.25	0.99	Nil	0.5

* Permanganate reducing figure.

TABLE II.
ANALYSES OF FRUIT SYRUPS.

No	Source.	Fruit.	Age (years)	Specific Gravity.	Acid %	Nitrogen (Organic) %	Protein (N x6.25) %	Total Ash. %	Principal Ash Constituents % of Total Ash.						Total Sugar %	Sucrose. %	Glucose. %	Fructose. %	Vitamin mgm/100 grs.
									K ₂ O	Na ₂ O	CaO	MgO	P ₂ O ₅	Fe ₂ O ₃					
9	Commercial Bulk	Strawberry	2	1.247	1.10	0.0183	0.114	0.346	47.86	0.82	5.71	4.08	7.64	0.90	49.5	7.9	20.9	20.8	14.3
9	"	Raspberry	2	1.268	1.15	0.0350	0.218	0.286	51.01	0.74	5.14	4.97	6.78	0.88	51.8	0.9	24.6	26.3	8.1
1	"	Black Currant	2	1.260	1.40	0.0153	0.096	0.428	49.40	0.64	6.56	2.77	5.88	0.73	50.7	1.7	23.8	25.2	71.2
2	"	Lovanyberry	3	1.250	1.25	0.0226	0.141	0.295	43.20	6.14	4.79	4.76	4.80	0.74	48.9	Nil	24.0	24.9	6.4
3	Long Ashton	Black Currant (Baldwin)	1	1.241	1.61	0.0200	0.125	0.456	48.75	0.99	7.79	3.97	7.47	1.37	—	—	—	—	101.3

The freezing method of Krause has recently been developed into a continuous process and represents what is probably the best method of concentration from the point of view of ultimate flavour.

Chemical Composition of Fruit Juices and Syrups.

Tables I and II give the data recently obtained at Long Ashton for some of the chemical constituents of commercial juices and syrups obtainable in this country, together with several experimental products made at Long Ashton. Table I refers to apple juice, whilst Table II is for pure fruit syrups.

The following remarks apply to the data in the two Tables :—

Table I.

Tannin.

The figures refer to the permanganate-reducing value of the juices. This figure is related to the astringency of the juices themselves. The tannin compounds confer a bitter character and a certain fullness on the juice.

Nitrogen and Protein.

The values for cider fruit are always much lower than those for dessert and cooking sorts. The Sussex juice was obtained from apples grown under arable culture combined with heavy manuring.

Ash Constituents.

The relative percentages of the various constituents of the ash are similar to those for whole apples. The outstanding feature is the high K_2O figure, and the enhanced percentage of CaO in certain juices where the abnormally high natural acidity of the fresh juice had made it imperative to remove some of the acid constituents with chalk.

Calcium Pectate.

These figures are difficult to interpret. The presence of 0.0874% of Ca pectate in the Bramley's Seedling juice is surprising in view of the very thorough nature of the depectinizing treatment. The juice, however, has kept in can for 12 months in a perfectly brilliant condition and in consequence it must be considered that the pectin is in a stable, soluble form.

Vitamin C.

The figures are all very low, but the methods of analysis included only "reduced" ascorbic acid and there is evidence that reversible oxidation may have taken place and that the total amount of the Vitamin present is considerably in excess of the figures given.

Table II.*Acidity.*

The acidities refer to the final, adjusted figures after citric acid had been added.

Nitrogen and Protein.

The amounts present are considerably in excess of those for apple juices.

Sugars.

Although the initial sugar content of soft fruit juices varies from 5—10%, this is raised to 55% in the syrups by the addition of pure, solid, cane sugar. The inversion of the added sugar is effected by the fruit acids and some time is needed for the complete inversion to take place.

Vitamin C.

The figures indicate the vast superiority of black currant over any other fruit from this point of view. It may be that the very slight fermentation which occurred in the raspberry, loganberry and strawberry juices previous to their being syrupe~~d~~ was responsible for the removal of some of the Vitamin.

Nutritional Significance of Pure Fruit Juices and Syrups.**Fruit Juices.**

Very few scientific data are available which have a direct bearing on the effect of the actual products under consideration, but Fawns and Martin in 1938 published a paper (The Chemical Composition of Fresh Apple Juice, *J. Soc. Chem. Ind.*, February 1938, Vol. LVII, pp. 60-65), reporting results of analytical work carried out on apple juices made by the cold process from Devonshire cider apples, from which the following abstracts have been taken :—

- (i) The results of the investigations indicate that most of the nutritional value of whole apples is retained in the juice.
- (ii) The sugar content of the juices varies between 65—90% of the average value found by McCance *et al* for whole apples. The total acid values for the juices lie around those for whole apples. There is, however, a large loss of nitrogenous constituents. . . . Examination of the individual ash constituents indicates that the mineral content of the original fruit is almost quantitatively recovered in the juice.
- (iii) From a dietetic point of view, the presence of the major constituents of whole apples in a liquid medium capable of absorption without preliminary digestion of vegetable tissue being necessary, is an obvious advantage.
- (iv) The values obtained for the calorific value of apple juices are of the same order as those quoted by Chaston Chapman for stout (*J. Inst. Brewing*, 1932, 38, p. 83). Comparison with his other figures shows the calorific value of apple juice to be considerably higher than that of mild ales, bitters, or lagers, and less than that of strong beers and old ales.
- (v) For comparison with a rich source of calories in fluid form, the average calorific value of milk is given as approximately 390 calories per pint. (Chapman, *ibid* & Mann, M.R.C. Spec. Rept. Ser. No. 105, 1926.) The average value for Devonshire apple juices was 280 calories per pint. It should be pointed out that the calories obtained by the consumption of apple juice are in a readily available form since the analytical figures indicate that they are derived mostly from simple hexose sugars, requiring no hydrolysis by digestive enzymes before assimilation can take place, as is the case with polysaccharides, fats or proteins.
- (vi) Ascorbic Acid (Vitamin C). The figures for ascorbic acid in Devonshire apple juices correspond to the figures for apple cortex in whole apples, but the bulk of the Vitamin, which is present in the skin, is lost to the juice. Preliminary trials have shown the presence of reversibly oxidized ascorbic acid in apple juice. Fermentation has a destructive action on the Vitamin.
- (vii) Mineral content. The most striking point is the high potassium content. Apples have long been recognized as an alkalogenic article of diet by reason of their ash content.

The organic acids present, viz. malic, with small amounts of citric and acetic, are metabolisable, so that the ultimate contribution to the acid-base equilibrium devolves on the mineral constituents which are alkaline by reason of the excess of basic radicals present. The same would appear to apply to apple juice, since average figures worked out from data for Devonshire juices show that the sum of Na, K, Ca and Mg is 45.4% of the total ash (56.7% calculated as oxides). This confirms the figures of Mehrlitz, who found that Na, K, Ca and Mg (as oxides) supply 63.7% of the total ash and P_2O_5 , SO_4 and Cl only 16.9%.

The dietetic value of apple juice as regards its mineral contents would thus appear to be its contribution to the building up of an alkali reserve.

The figures from Fawn's and Martin's paper are not given here, but similar figures have been obtained at Long Ashton on juices and syrups and are given in Table I in the previous Section. The high CaO content of several of the juices is the result of the use of pure precipitated chalk to reduce the acidity. It is not known whether the actual amounts of calcium, phosphorus and iron are of any importance from a nutritional point of view, but their presence is at least significant.

Fruit Syrups.

The analyses of fruit syrups, many of which are of samples taken from large commercial bulks of the products, indicate two special points of interest which are not shown by the apple juices. In the first place, the large amounts of sucrose added at the time of the syruping operation have been completely inverted into the easily assimilable glucose and fructose hexose sugars. This fact suggests that fruit syrups of this type constitute valuable sources of energy which are quickly available to the human system. Other products which are sweetened with cane sugar immediately prior to sale or consumption do not possess this advantage to the same extent.

Secondly, the Vitamin C content of black currant syrup is very high. In the original fresh juices, figures as high as 224 mgs/100 cc. juice have been obtained from a variety known as Westwick Choice, and although some proportion of this is lost during processing and storage, the residual percentage is such that black currant syrups of the type under consideration are still most valuable sources of ascorbic acid. The scientific exhibits shown at the Conference

include the results of experiments which indicate that under the conditions of commercial procedure obtaining during the cold processing of fruit syrups, Vitamin C is fairly stable and can be retained to a considerable extent in the syrups.

The mineral constituents of syrups are similar in amount to those for apple juices. The iron content is not so high as in apple juices, but it is probable that some of the iron has found its way into the juices during the processing and was not present in the fresh apples or berries.

Milk Shakes.

The writer wishes to emphasize the extreme importance of recognizing the valuable nutritional elements contained in milk shakes made from pure milk and pure fruit syrups. The high Vitamin C content and the easily assimilable sugars of black currant syrup and the well-known food value of the milk combine to produce a beverage of nutritional importance. It is suggested that the decline in the "milk in schools scheme" may be arrested by serving milk shakes made with a range of fruit and other products, by varying the flavours day by day and thus avoiding the monotony of the flavour of pure milk, which apparently was the cause of the dislike of the drinks. Experiments in certain schools are strongly urged as being a useful way of determining whether any such scheme would be generally feasible.

Canned Black Currant Syrup.

In view of the high Vitamin C content of black currant syrup, it is considered necessary to investigate the possibility of such a product being of national importance in times of war or other emergency. The possibility of restriction or cessation of supplies of citrus fruits or fresh juices from abroad must be examined, and, in the eventuality of such a position arising, supplies of black currant syrup (preferably canned on account of danger from poison gas) may become of great importance.

Recent Nutritional Data.

German medical specialists (Heupke, Noorden, Neusser, etc.) have recently published recommendations regarding the use of fruit juices from the dietary point of view. Apart from the points

already mentioned the following three factors are considered to be of great importance in the prescribing of fruit juices :—

- (a) Their relative paucity in albumin.
- (b) Their lack of fats.
- (c) Their extremely low content of NaCl.

Heupke considers that fruit juices are valuable antidotes to the high albumen diet of urban populations. They are of great value in treating cases of inflammation of the kidney due to the inability of these organs to remove the daily products of decomposition of diets rich in albumen. Noorden (Vienna) states that juices have been used with good effect in the case of fever patients who are inclined to sweat (*e.g.* tuberculosis).

Finally, information has recently been received that apple juice is one of the few forms of nourishment allowed to patients undergoing the injection treatment for advanced cancer in the various clinics recently established for that purpose in England.

A Harley Street specialist has written the following note : 17/3/39: " I have for the past few years employed fruit juices very freely in the diets of those to whom fruits and vegetables in natural forms are forbidden (such as gastric ulcer, ulcerative colitis, diverticulosis, etc.), and in addition I use them in all prolonged infective or debilitated states. Apple juice has been a welcome addition and has stimulating qualities (as far as one can gather clinically) in addition to the obvious nutritive and Vitamin value."

Medical Significance of Pure Fruit Juices and Syrups.

The need for absolute proof of the efficacy of a given material for the cure of a disease is so insistent to-day that the results of none but the most carefully planned and executed experiments can have any significance in building up a reasoned and satisfactory case for the use of any such materials in medical practice. But whilst the actual complete proof and understanding of fruit juice treatments may not yet be completely apprehended, there appears to be a mass of evidence of a very general nature indicating that fruit juices may possess some curative properties. It is not intended here to make more than brief allusions to information which has been obtained with some difficulty from Germany and Switzerland. Fuller details are being prepared and will be made available later.

- (i) Heupke reports that a disease of children in Central Europe, involving retardation of development and persistent anaemia, may be successfully treated with fruit juices.
- (ii) Fruit juices are now playing a prominent part in the treatment in Germany of diabetes. A maintenance diet of glucose and fructose is available without fat and albumen through the consumption of juices, and apparently the system is assisted in reducing sugar secretion.
- (iii) Dr. Fuhrmann in Germany has used fruit juices for over 60 cases of inflammation of the lungs in which fever symptoms were apparent to varying degrees. The problem is apparently that of nourishing the patient without at the same time increasing the fever. Fuhrmann found that it was not necessary to have recourse to heart stimulants, for the effect of the juice was to invigorate the circulation, and the general condition and recovery, after subsidence of the fever, was very quick.
- (iv) This experience has been checked and confirmed in the general division of the Rudolph-Hess Hospital, where fruit juices are now given to all patients, adults and children, suffering from inflammation of the lungs.

In England interest has been centred round cases in which patients suffering from hyperacidity with duodenal ulceration have been treated with National Mark black currant syrup and a group of sick children have been given apple juice. The evidence is added here in some detail.

Treatment of Hyperacidity with Black Currant Syrup.

With reference to the pure fruit syrups marketed under the National Mark scheme, the black currant product was recommended by the writer five months ago to a local doctor who desired to find a liquid source of Vitamin C which was at the same time palatable and acceptable to the patients. The following notes have been given by the doctor concerned :—

The black currant syrup was prescribed to 10 cases, all suffering from hyperacidity and most from ulceration of the stomach or duodenum. In every case, considerable alleviation of symptoms, especially of pain, followed the use of the syrup, and in one or two cases very remarkable recoveries were made. Up to the present time, which is admittedly only five months from the inception of

the use of black currant syrup for this doctor's patients, there has been a relapse in only one case, which has been recommended for operation.

In the case of two patients, one a female adult and the other a young girl, attempts had previously been made to introduce Vitamin C of fruit origin into the system. The patients, however, were incapable of taking oranges, lemons, strawberries, raspberries in the fresh state or their respective juices. Black currant syrup, however, was taken with relish and its use was followed by greatly improved health.

The syrup used for these cases possessed the analysis given below :—

Sugars	..	..	Fructose	25.4%
			Glucose	26.0%
			Sucrose	1.7%
Ash	..	..		0.36%
Iron	..	...	11 parts per million.	
Vitamin C	..		77 milligrammes per cc. or	
			61 milligrammes per 100 grammes.	

The contents of Vitamin C and iron are possibly connected with the curative properties of the syrups.

An interesting feature of all the 10 cases is the fact that the patients, many of them living in very poor conditions, are continuing the treatment at their own expense. It appears to be a feature of all such cases that the patients regard their "medicine" in the light of a beverage.

The above observations have been amply confirmed in numerous other cases in which black currant syrup has been casually introduced to a variety of people by those interested in its production. In Bristol alone, many cases have been reported in which persons suffering merely from acute indigestion or from duodenal inflammation have found more or less complete relief by the use of this pure fruit product, and the syrup is being used for many forms of stomach disorders of children.

Treatment of Pink Disease with Apple Juice.

The first apple juice treatments were carried out under strict medical supervision at a Yorkshire hospital in 1937, using apple juice supplied by Long Ashton Research Station. The doctor's report is given here :—

“ Case 1. A child, E.M., aged one year, who had been ill for several weeks before she was admitted to my care on 12/7/37. She was sent in because the doctor had noticed that the child was getting worse and the parents were unable to nurse it any longer through loss of sleep. The child presented the typical features of Erythroedema (Pink Disease), extremities cold and discoloured. It was extremely fretful, suffered from hypotonia, and disliked light. It had some local soothing treatment, and numerous lines of general treatment were tried without the slightest success.

I remembered reading about apple juice, and on application to Long Ashton we were supplied with the necessary bottles. The dose to begin with was one teaspoonful three times daily and this was increased to four-hourly.

The child was discharged 14/10/37, the condition had improved, and the general appearance and demeanour was in striking contrast to that on admission. The treatment was carried out for some time at home.

Case 2. This child was 1 year and 1 month on admission 23/7/37, and was an even more marked example of the condition, being very fretful and much more difficult to manage.

The apple juice treatment four-hourly was the only treatment tried here, and when the child went home 10/11/37 it was very much improved.

I have made enquiries as to the subsequent course of these cases and am informed that there has been no relapse and that the children are now well and are developing normally.”

A further significant treatment occurred late in 1938 as a result of the writer learning by pure chance of the serious condition of the baby of a former member of Staff of the Research Station. The details supplied by the father are as follows :—

“ The baby was bottle-fed, and after seeming to make good progress as far as weight was concerned for five months, she suddenly refused her food, stools became abnormal, considerable perspiration ensued, accompanied by high temperature and pink colourings of the hands and feet. After consultation with local doctors for a fortnight the baby was taken to see a specialist in Wimpole Street. The trouble was diagnosed as Pink disease and the parents were advised to take the child to a London hospital immediately. Her condition gradually became worse and the continuous high temperatures

rendered her liable to inter-current infection, and in addition to Pink disease she contracted seven other complaints, including pyelitis, bronchitis and various urine troubles. After three weeks she was transferred to a London hospital for children. Her condition continued to deteriorate, although short periods of improvement occurred. Various medicines were tried. These included Vitamin preparations such as liver extract, radio-stoleum, and a concentrated Vitamin A extract. A blood transfusion gave a negative result. Prontosil was given primarily for urine streptococcal infection.

After four months, the parents were requested to meet the specialist, who appeared to take a grave view of the baby's condition. The alternatives presented were :—

- (a) A quick improvement.
- (b) Breakdown of some vital organ.
- (c) In the event of a gradual recovery from the existing troubles she might be left with some permanent affliction.

Towards the end of October, the parents learnt by phone that the baby had collapsed and might not live through the night. Three days later the parents were called to the Hospital from their home in Maidstone and were prepared to hear the worst news on their arrival. During this period no nourishment could be kept down and the specialist had recourse to intra-venous glucose injections. At this time, the writer learnt of the case for the first time, and with the Yorkshire cases in mind took the responsibility of suggesting that apple juice should be tried. Samples were sent, analyses were provided and the juice was given in very small doses. Almost immediately the baby showed slight improvement, and when, a little later, food was re-commenced, there was hardly any vomiting, stools were more normal and the temperature dropped. There was a reverse after a week and glucose was again introduced by the needle. However, within three weeks of the administration of apple juice, the child was able to leave hospital, and from a baby "that was grotesque and pathetic" she has become a fine good-looking baby, taking a delight in her food and gaining weight regularly.

The apple juice was stopped in February 1939, but was soon commenced again, as the symptoms of Pink disease, which had never completely disappeared, became more frequent and the food was taken with less enjoyment."

The above case cannot be cited as showing that the apple juice has completely cured any one precise disease, but the results are of

such a nature that they have been thought worthy of being put on record in this manner.

In addition to the above specific cases of treatment there is a growing series of individual cases in which relief from various complaints has followed the consumption of the liquid products with which this communication is concerned. It is not the present intention of the writer to suggest in any way whatever that pure fruit juices are destined to become important dietary or medicinal products, but the co-operation of the medical profession is earnestly invited in order that the true facts and significance regarding their use may be discovered to avoid any false claims being made in the future.

It would appear that useful information would result from an investigation on this matter carried out under conditions which would be considered satisfactory by the medical profession.

THE MANURING OF CRICKET-BAT WILLOW TREES.

By H. P. HUTCHINSON.

Up to the present time it has not been possible to supply fully the information which has been asked for by numerous enquirers on the manuring of Bat-willow trees on account of the non-existence of any results based on direct scientific evidence. Bat willows grow well when plentifully supplied with such organic matter as exists in sewage areas and near manure heaps, and applications of farmyard manure around the trees are claimed to increase the rate of growth. These facts, supported by the results obtained at this Station on the manuring of Basket-willows, wherein the prime importance of nitrogen was proved(1), were the reasons for confining the experiment to the use of nitrogen. Sulphate of ammonia was used as being a source of supply of this element in a soluble form.

The differences in the volumes of the boles of the treated and untreated trees were taken as indicating the value of the fertilizer.

The Experiment.

Forty-two Bat-willow trees, 4 years old, were used. They were growing at Long Ashton in block formation 27 feet apart on a non-flooding permanent meadow, the soil of which was a drift loam of considerable depth. In order that the fertilizer should not be intercepted by the grass, the following preparatory measures were taken. In July, 1936, the whole of the grass was cut and the crop spread around the trees to a distance of 6 feet from the bases of the boles, as a mulch. The effects of this operation were to kill the underlying grass, to conserve soil moisture, to enable rain to pass freely to the roots of the trees and to form a humus medium for new root development.

First Application. On February 4th, 1937, 2 lbs. of sulphate of ammonia were given to each of half the number of trees in the block in alternating order by spreading it on the mulch. Measurements of the boles were taken on the same date. Leaf burst occurred towards the end of March and growth proceeded without any abnormal check until the end of the year. Differences in the appearances of the treated and untreated trees such as might have occurred in the leaves or bark could not be detected at any time. The grass around the edges of the mulch was greener and denser

in the case of the treated trees and was the only means of distinguishing them from the rest.

The rainfall during the growth period was as follows :—

YEAR 1937.				
February	..	..	5.16 inches	} 13.82 inches.
March	..	..	3.48 "	
April	..	..	2.62 "	
May	..	..	2.56 "	
June	..	..	1.41 "	} 7.41 "
July	..	..	3.99 "	
August	..	..	2.01 "	
Total	..	..	21.23 "	

It has been ascertained from other experiments that the rate of increase in girth of a bat-willow tree is slow until the end of May. It rises rapidly in June and attains the optimum in July and August, falling rapidly and suddenly in early September. The rainfall to the end of May being 13.82 inches suggests that there might have been considerable loss of fertilizer before maximum root absorption could take place owing to leaching.

The trees were measured in October 1937 from which the volumes were calculated :—

MANURED TREES.				UNMANURED TREES.			
Tree No.	Vol. in Cubic Inches.		Increase	Tree No.	Vol. in Cubic Inches.		Increase
	Ap. 1937.	Oct. 1937.			Ap. 1937.	Oct. 1937.	
1	810	1346	536	2	102	235	133
3	156	433	277	4	276	609	333
5	170	439	269	6	333	735	402
7	102	295	193	8	142	418	276
9	222	546	324	10	928	1287	359
11	706	1197	491	12	650	1297	647
13	148	381	233	14	146	405	259
15	172	422	250	16	305	698	393
17	120	346	226	18	1162	1882	720
19	297	773	476	20	632	1379	747
21	1225	2160	935	22	305	856	551
23	427	1034	607	24	143	457	314
25	229	604	375	26	660	1060	400
27	533	1312	779	28	438	720	282
29	987	1599	612	30	122	251	129
31	127	438	311	32	333	664	331
33	609	1312	703	34	1254	1860	606
35	155	371	216	36	355	568	213
37	879	1505	626	38	258	409	151
39	84	154	70	40	284	474	190
41	123	377	254	42	399	594	195
Total Vols.	8281	17044	8763	Total Vols.	9227	16858	7631

The figures show.

- (1) That the increases in volumes over the previous year's volumes were, for treated and untreated trees, 8763 and 7631 cubic inches, or 105% and 82% respectively.
- (2) That by volume ratio the treated trees would have increased by 6849 cubic inches without fertilizer. Therefore 8763-6849, or 1914 cubic inches is the increase in the amount of timber due to the application of 42 lbs. of sulphate of ammonia.
- (3) That taking the value of Cricket-bat willow timber at 21/- per cubic foot and the price of sulphate of ammonia at 9/- per cwt., 3/6 worth of fertilizer produced 23/3 worth of timber.

In July, 1937, the grass crop was cut and the whole of it used as mulch for the trees as in the previous year.

Second Application. On February 10th, 1938, 2 lbs. of sulphate of ammonia were given to the same trees as received it in 1937.

Measurements were taken at the same date.

The unfavourable weather of early spring checked growth, but in early June growth became very vigorous. From this time to the end of the growing season the deeper green of the manured trees, the greater amount of lenticel development and the more numerous growth cracks on the bark served as a very ready means of distinguishing treated from untreated trees.

The rainfall records for the annual growth period were :—

YEAR 1938.				
February	..	..	1.11 inches	} 4.01 inches.
March	..	..	0.46 "	
April	..	..	0.25 "	
May	..	..	2.19 "	} 8.59 "
June	..	..	1.29 "	
July	..	..	3.94 "	
August	..	..	3.36 "	
Total	..	..	12.60 "	

The total rainfall from the time of application of the fertilizer to the end of May was 4.01 inches which, when considered against the 13.82 inches which fell in the corresponding period of 1937, could not suggest loss by leaching but might have been insufficient to carry

the nutrient solution to the root region. The trees were measured in October, 1938, and the volumes of the boles ascertained as follows :—

MANURED TREES.				UNMANURED TREES.			
Tree No.	Vol. in Cubic Inches.		Increase	Tree No.	Vol. in Cubic Inches.		Increase
	Ap. 1938.	Oct. 1938.			Ap. 1938.	Oct. 1938.	
1	1346	2250	904	2	235	461	226
3	433	982	549	4	609	1054	445
5	439	909	470	6	735	1216	481
7	295	682	387	8	418	852	434
9	546	1181	635	10	1287	1976	689
11	1197	2148	951	12	1297	2040	743
13	381	856	475	14	405	779	374
15	422	883	461	16	698	1268	570
17	346	786	440	18	1882	2709	827
19	773	1635	862	20	1379	2249	870
21	2160	3917	1757	22	856	1452	596
23	1034	2007	973	24	457	865	408
25	604	1296	692	26	1060	1788	728
27	1312	2491	1179	28	720	1217	497
29	1599	2793	1194	30	251	387	136
31	438	1019	581	32	664	1037	373
33	1312	1936	624	34	1860	2763	903
35	371	726	355	36	568	1051	483
37	1505	2488	983	38	409	639	230
39	154	245	91	40	474	741	267
41	377	799	422	42	594	858	264
Total Vols.	17044	32029	14985	Total Vols.	16858	27402	10544

The figures show.

- (1) That manured trees increased in volume by 80%, and the unmanured trees increased in volume by 63%.
- (2) That by ratio 14985-10660 or 4325 cubic inches is the increase in timber due to the application of 42 lbs. of sulphate of ammonia.
- (3) That by assuming previous values for the timber and fertilizer $3/6$ worth of fertilizer produced $52/6$ worth of timber.

Conclusions.

1. In this experiment the importance of nitrogen as a fertilizer for Bat-willow trees has been demonstrated.

2. Sulphate of ammonia has been proved to be a satisfactory source of supply of nitrogen.

3. Two lbs. of sulphate of ammonia per tree gave good results, but the limits of quantity economically possible to use on such trees did not fall within the range of the experiment and the relationship between quantity of fertilizer and age and size of tree still remains to be determined.

4. The time of application (February) was chosen because it had been observed that in normal years at Long Ashton, where the soil is a deep retentive loam, root growth of willows begins in this month. In more open soils, where waste due to leaching might occur by a too early application, the fertilizer might with advantage be deferred. Further experimental work is needed on this problem.

5. The method used of preparing the trees for reception of the fertilizer is applicable to most cases, there being generally an abundance of grasses and strong growing plants where Bat-willows are grown. Besides conserving moisture the vegetable matter rapidly decomposes and forms a medium into which new roots grow. In carrying out this operation—

- (a) The mulch should be thick enough to kill the underlying vegetation.
- (b) Should not be placed in contact with the bole of the tree.

Summary.

An experiment is described, having as its object the ascertaining of the value of nitrogen in the form of sulphate of ammonia as a fertilizer for Cricket-bat willow trees.

The results are recorded as values of amount of timber produced relative to the amount of sulphate of ammonia used.

REFERENCE.

- (1) HUTCHINSON, H. P. "Manurial Requirements of the Basket Willow." *Annual Report.. Long Ashton.* 1924.

REPORT ON ADVISORY WORK, 1937-1938.

The number of enquiries shown in the statistics for 1938 for the Department, which are directly comparable with those for 1937, shows an increase of 779 in a total of 7,232, the highest number ever recorded. The increase is almost wholly due to large increases in the work of the two sections—Agriculture and Agricultural Chemistry (+496) and Dairy Bacteriology (+299). In the former of these two cases the expansion of the work is to be attributed to developments arising from the Land Fertility Scheme.

As in previous years no statistics are included for Agricultural Economics, where the volume of work has been similar to that of the previous year, nor for the Poultry Pathology service in connection with blood testing and post-mortem examinations. In the latter section there has been a further large decrease in numbers of samples received for blood tests, the total of 85,044 for 1937 falling to 50,098 in 1938. On the other hand the number of pathological specimens received has increased from 1,762 to 2,066. The decrease in blood tests is attributed to the precarious state of the poultry industry and to a "waiting" policy adopted by many poultry farmers in connection with the report of the Poultry Technical Committee, and is not to be regarded as a lack of appreciation on the part of the poultry industry in the work of the Poultry Laboratory.

The statistics given in the table below refer to fourteen subjects, four of which relate to the work at the Berkeley Square Centre and ten to subjects at the Long Ashton Institute.

At the Berkeley Square Centre there is a nett increase of 802 enquiries, due primarily, as stated previously, to large increases in the Agriculture and Agricultural Chemistry and Dairy Bacteriology sections. Actual figures for the various sections are as follows :—Agriculture and Agricultural Chemistry (+496), Dairy Bacteriology (+299), Veterinary Science (+18), Poultry Pathology (—11).

The Long Ashton subjects show an insignificant change in the total (—23), and most of the variations for the different subjects are merely the normal fluctuations to be expected due to seasonal characters and changes in practical problems of growers and others

in connection with various subjects of investigation. The changes for the various sections are as under:—Cider (—83), Cider Instruction (+5), Fruit Products (—40), Pomology (—76), Horticultural Chemistry (+63), Economic Entomology (+24), Economic Mycology (+44), Insecticides and Fungicides (+47), Domestic Preservation (—41), Willow Growing (+34).

The largest changes are in Cider and Fruit Products, both decreases, and in Horticultural Chemistry where an increase has occurred. Cider enquiries have fallen off during the past two years from a level which was probably abnormally high due to the special interest taken in Cider-making in relation to the cull fruit problem before the advent of Apple Juice, so perhaps enquiries are tending once more to reach a more normal level. Although the number of enquiries relating to Fruit Products shows a decrease, the actual volume of work entailed with enquiries was larger than ever, since the initiation period of the various industries concerned is passing and actual factory problems of production are being sent to the Institute. Some idea of the advisory work involved will be obtained by the fact that during the year the Fruit Products Officer granted 131 interviews at Long Ashton to manufacturers and growers, involving approximately the time of 50 working days.

In certain sections of the Department it was necessary to curtail advisory work in certain areas over the period December 1937—February 1938, owing to the widespread outbreaks of Foot-and-Mouth Disease in the counties of the Province. This same cause seriously affected the work of the Cider Instructor in Dorset from September 1937—March 1938. Under these circumstances work was continued as far as possible by means of correspondence.

At the Berkeley Square Centre it is gratifying to note the excellent progress made under the Land Fertility Scheme, and to see that one outcome of the Scheme is an increase in general advisory work in Agriculture and Agricultural Chemistry apart from the subjects of Lime and Slag. The influence of the working of the Scheme should be especially important in view of the fact that particular attention is being given to backward areas under the Soil Lime and Phosphate Surveys of the Scheme.

In the Fruit Products Section the year has witnessed marked advances towards the establishment of a Fresh Apple Juice industry in the Country, and it is hoped that the coming year will see still further progress made.

In Pomology, the section has again been called upon to receive

large numbers of visitors and parties at Long Ashton, and the staff of the section have given much of their private time in this way.

Under Cider Instruction, the three counties of Dorset, Monmouth and Worcester have again all participated in the scheme for the whole year. The Instructor, with the Soil Surveyor, is carrying out special Orchard Surveys in the counties with a view to placing advisory work on orcharding on a sound basis.

The Pathological Sections once more offered to growers in the Province considerable help in the control of pests and diseases by continuing the Spray Programme Service. Under this scheme notices were broadcast, through County Officers, regarding the correct spraying dates for Plum and Apple Sawfly, Red Spider, Raspberry Beetle and Codlin Moth. In the Insecticides and Fungicides section very close co-operation was again maintained with manufacturers of spray materials, and the chemist concerned with insecticides and fungicides has been busily engaged, in co-operation with technical officers of the Ministry of Agriculture and Fisheries and of the Association of British Insecticide Manufacturers, in drawing up specifications with a view to standardizing certain important spray materials. This work should eventually be of great value to the fruit growing industry.

The advisory work in the present report is classified under fourteen heads, viz.:—Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Poultry Pathology, Cider, Fruit Products, Pomology, Horticultural Chemistry, Economic Entomology, Economic Mycology, Insecticides and Fungicides, Domestic Preservation of Fruit and Vegetables and Willow Growing.

The statistics which are given relate to all subjects excepting Agricultural Economics where the method of working does not lend itself to statistical tabulation of enquiries as a means of assessing the work of the section, since the personnel concentrate on special problems of groups of farmers and on economic surveys of farming methods and special rural industries, and normally only consider the particular cases of individuals as they arise in group and survey studies.

Under Poultry Pathology only enquiries which are dealt with by the Poultry Pathologist on behalf of the Veterinary Investigation Officer are included.

The number of enquiries submitted to the Department during the past six seasons are summarized in the following table:—

	Year ending September 30th.					
	1933	1934	1935	1936	1937	1938
Gloucester (including Bristol) ..	849	945	1602	1622	1730	1775
Hereford	310	337	360	497	275	337
Somerset	810	997	1119	1138	1118	1459
Wiltshire	481	476	1365	848	1007	1328
Worcester	455	496	528	509	360	520
Other Areas	1217	1562	1571	1872	1963	1813
	4122	4813	6545	6486	6453	7232

The figures are shown separately in the table for the five counties which comprise the Bristol Advisory Province and for Other Areas. In this latter category are included enquiries from Devon and Monmouth, both of which contribute annual grants to the Long Ashton Institute, and from Dorset under the Cider Instruction Scheme. These counties do not rank officially as part of the Bristol Province, though an arrangement is in force whereby Monmouth is recognised as part of the Province for advisory purposes relating to Horticulture. Close touch is maintained with the personnel of all three counties through the medium of the Horticultural Sub-Committee of the Provincial Advisory Council.

The data do not include the numerous enquiries dealt with in personal interviews during survey work, local investigations, shows, etc.

The following features referred to in the sectional reports which follow call for special attention :—

Agriculture and Agricultural Chemistry.

The Land Fertility Scheme and the Soil Lime and Phosphate Deficiency Surveys have stimulated amongst farmers an increased interest in Agricultural Education and Research and, as a result of additional grants received from the Ministry, it has been possible to deal with a greatly increased number of requests for advice and samples for examination and report. The soil work carried out to date indicates that the soils of much of the Province, particularly in the "backward" areas, are deficient in lime, phosphate and potash. The amelioration of the two former deficiencies is a

relatively simple matter under the Land Fertility Scheme, but potash deficiency is likely to present an ever increasing and most serious problem.

Apart from the normal routine enquiries concerning crop failures, livestock problems and the agricultural value of by-products from local industries, a large amount of investigational work has been undertaken, more especially in connection with grassland and poultry.

The investigation of the composition of hays which is being carried out for the Bath and West and Southern Counties Society has revealed that the mineral content of hay is very low on certain farms, and far below the level necessary if the minimum requirements of store stock and sheep in the winter months are to be supplied by hay (and roots) alone.

The study by means of field investigation and laboratory analyses, of the "lime" value of Basic Slag, which is being conducted for the British Basic Slag Corporation, is being continued. Data for the first two years of the experiment indicate that, in its effect on the yield and composition of herbage, a top dressing of basic slag is equal to a combined dressing of superphosphate and ground limestone containing equivalent amounts of phosphoric acid (P_2O_5) and lime (CaO).

The publication of the University of Bristol Bulletin, No. 20, "The Maintenance of Grassland for Poultry, and the Storage and Utilization of Poultry Manure," has stimulated great interest in these subjects amongst poultry farmers and others. Other work with regard to the treatment of poultry runs, nutritional disorders in poultry, and "green yolk" in eggs is in progress.

Thirty-five evening broadcast talks to farmers were given in the West of England and other B.B.C. programmes. Other Advisory Officers attached to this centre and to other counties, and research workers from Long Ashton Research Station as well as County Organizers, farmers and growers have participated in these talks.

Dairy Bacteriology.

Although the presence of Foot-and-Mouth Disease in the Province caused much of the advisory work to be suspended for three months, the number of requests for advice exceeded that for the previous year by 299. The number of advisory samples examined increased by 207, and the total number of samples from all sources exceeded the previous year's figure by 257.

In addition to the Annual Clean Milk Competition held in Worcestershire, and the Gloucestershire Milk Recording Society's Competition, a competition confined to County Council Smallholders was conducted in Wiltshire and proved very successful. The Wiltshire Milk Testing and Advisory Scheme continues to function smoothly, and a similar scheme has been commenced in Worcestershire. The examination of official graded milk samples for the County Councils of Wiltshire and Gloucestershire continues to be conducted by the University at the Advisory Centre.

More than the usual number of cheese problems were brought to the notice of the Dairy Bacteriologist, and an increased number of water samples have been examined. An interesting case of coliform-infected milk was reported and investigated by the Dairy Bacteriologist. Investigational work on the Methylene Blue Reductase Test has been continued.

Agricultural Economics.

The second year of the new Farm Management Survey was completed, although considerable delay was caused by the outbreak of Foot-and-Mouth Disease. The total number of completed accounts was raised from 143 to 180. Summaries of the accounts by type-of-farming districts have been issued. The results for 1937 reveal a decline in profits compared with 1936.

Four years have now been completed in the Milk Costing Investigation. The number of farmers co-operating has been maintained. Summaries of results have been issued as usual. The enquiry into the economics of feeding has been continued. Special attention has been paid to the cost of production of hay.

Investigations have continued into the costs of pig and poultry production. Fourteen farmers have co-operated in each scheme. Special attention has been paid to feeding efficiency and farrowing records in the pig scheme, and to the analyses of income and expenditure in the poultry scheme.

Commencing with February 1938, a new monthly publication has been issued, entitled "Notes on Farm Economics," with the object of keeping those farmers who are co-operating in the various investigations more fully informed of the results obtained.

Veterinary Science.

The work has been steadily maintained, and there have been further increases in the number of requests for advice and of pathological specimens submitted.

The diseases encountered were many and varied, the more important are appended.

Internal parasites, mainly stomach worms and liver fluke, have been rather more prevalent among sheep than in the former year.

Contagious pustular dermatitis has caused serious losses in some flocks, particularly where secondary infections of the udders of the ewes occurred.

Work in connection with the eradication of contagious bovine abortion is proceeding and blood tests of all cattle are being carried out on five farms.

Parasitic gastritis of young cattle was particularly prevalent during the summer months and caused quite serious losses on a number of farms.

Other conditions encountered in cattle were heavy liver fluke infestations and bracken poisoning.

Poultry Pathology.

Although the total number of blood samples submitted for examination was much lower than in the previous year, the number of pathological specimens received was higher.

The diminution in the number of blood samples submitted, and also the requests for advice must be attributed to the precarious state of the poultry industry, necessitating the closing down of numerous poultry farms, and the "waiting" policy adopted by many poultry farmers pending official action under the State Service.

Arrangements have now been made, in collaboration with the counties of the Province and the Ministry of Agriculture, to extend further facilities offered by the University, and it is hoped that with the financial assistance approved by the counties, and that asked for from the Ministry of Agriculture and Fisheries, the Poultry Pathological Section may continue its useful work in the field of poultry husbandry, particularly in assisting poultry farmers in the eradication of disease from their flocks.

Economic Entomology.

The number of enquiries concerning Agricultural and Horticultural pests did not show any appreciable variation from the previous year.

The Spray Programme Service dealing with the control of fruit pests was continued. A better distribution of the information supplied by the Research Station to the Provincial Agricultural Authorities would be appreciated by growers.

Apple Sawfly infestations were of exceptional severity in some plantations where applications of post-blossom washes were omitted due to an over-estimated loss of blossom by frost.

Severe attacks of aphides on all fruit crops were recorded throughout the Province, in most instances due to inadequate winter washing, followed by exceptionally favourable climatic conditions for aphid reproduction.

Fruit Tree Red Spider infestations were severe, particularly on plums and apples which had not been sprayed at petal-fall. Attacks of Greenhouse Red Spider of exceptional severity were noted on hops.

The application of insecticides by means of atomization is attracting considerable attention in the Province, more particularly as a means of controlling the pests of Brassica crops.

Amongst troublesome species on agricultural and market garden crops may be mentioned the Swede Midge (*Contarinia nasturtii*) which affected a wide range of Brassica crops, and the larva of a Chafer Beetle (*Phyllopertha horticola*) which caused serious injuries to pasture land in a number of localities. The Cabbage Root Fly (*Chortophila brassicae*) was again prevalent, whilst the eelworms *Heterodera schachtii* on peas and potatoes, *H. marioni* on tomatoes, and *Aphelenchoides ritzema-bosi* on chrysanthemums were notable.

The Mite (*Tarsonemus spirifex*) again occurred on oats in Wiltshire.

The Strig Maggot (*Contarinia humuli*) caused exceptional damage on hops, especially in Herefordshire.

A number of enquiries were received regarding Ant Hills in old pastures and their possible control.

Field trials with calomel gave a good control against the larvae of the Cabbage Root Fly (*C. brassicae*) in extensive field trials near Evesham.

Economic Mycology.

The number of advisory enquiries dealt with by letter was 542, compared with 498 last year.

Mr. D. L. G. Davies completed his Ph.D. thesis on "Fusarium

Diseases of Crops in the Bristol Province" in November 1938. Mr. E. H. Wilkinson has continued his post-graduate research on "Apple Fruit Rots and Spots," and has also worked under the direction of Mr. Marsh on Apple Canker.

The investigations on cuprous oxide and zinc oxide as Seed Protectants have been continued. Increases in germination of peas were secured in the middle of the summer, while out of 32 varieties none were harmed by cuprous oxide; some varieties appear to be especially susceptible to pre-emergence damping-off.

Attempts to control celery blight by seed treatments were unsuccessful.

It was found that both pre-emergence and post-emergence damping-off could be controlled by watering seed boxes, *after sowing*, with weak solutions of formalin. (1—200 to 1—600).

The biology and control of Asparagus Rust is being closely investigated by H. E. Croxall and the Adviser, the main point of interest being overwintering of the teleutospores, prolonged germination of uredospores, and parasitism of the rust by *Darluca filum*.

Dr. G. C. Ainsworth has now completed a detailed investigation of lettuce mosaic and this, in combination with the Adviser's own observations, is ready for publication.

Further progress was made in the classification of lettuces. Five groups were differentiated on the basis of flower and leaf characters.

A pot trial carried out by D. L. G. Davies indicated that the pH of the soil was unimportant in White Rot infection of Onions. There are indications that certain manurial treatments have a controlling effect.

Strains of Dwarf Beans selected for resistance to Dwarf Bean Foot Rot (*Fusarium Solani* var. *Martii*) gave highly successful results on infected ground near Evesham.

Seeds of varieties of Dwarf Beans resistant to Halo Blight have been obtained from Australia, while the Adviser has recommended varieties for trial both in Australia and Tanganyika.

Certain varieties of peas resistant to *Fusarium* wilt in the U.S.A. were found to give highly satisfactory growth on ground infected with "Pea Sickness" at Brentforton, the variety "Gilbo" being most conspicuous.

Investigations on Bacterial Disease of Begonias have been

completed, and a paper published in conjunction with Dowson and Moore. The organism is *Pseudomonas Begoniae* (Buchw.) Pape emend Dows. Infection is probably largely induced by watering the plants from tanks in which debris has been allowed to collect.

Splitting of Lily flowers, under glass, was shown to be due mainly to early infestation with aphides. Seed protectants are apparently of little value on lily seeds.

Willow Growing.

The market prices of English grown willows have continued to rise, and have now reached a point at which the willow crop may be regarded as being economically profitable. The present prices probably explain the fact that enquiries relative to the planting of new ground have been more numerous and keener than in late years.

The exhaustion of basket-making material which grows naturally in the native forests has resulted in the necessity of establishing Basket Willow Beds in Mauritius, Kenya and Tanganyika. The willows are intended to make baskets required in the coffee, tea and cotton plantations. Sets of suitable varieties of basket willows have been supplied by the Station.

Cricket-bat willow timber of good quality is still scarce, and prices at from 21/- to 25/- per cubic foot are readily made. Although the increase in planting during the past five years has been considerable, bat makers and merchants view with some alarm the prospects of obtaining sufficient suitable material ten years hence. The method of raising and management of Bat Willow trees, devised at this Station, is now extensively practised.

The salient features of the work of each section during the year are summarized below :—

AGRICULTURE AND AGRICULTURAL CHEMISTRY.

A further increase in the volume of advisory work has to be recorded, and that is in spite of the work being seriously held up during the period December 1937–February 1938 on account of the outbreak of Foot and Mouth Disease in the Province.

The additional grants received from the Ministry have made it possible to cope with the increased volume of advisory work, arising more particularly out of the Land Fertility Scheme.

During the year ended September 30th, 1938, 1,456 requests for advice were received. This is an increase of 496 over the previous year. 342 visits were paid by the Adviser and his assistants, and 1,668 samples of soils, fertilizers, limes, etc., were examined.

Advisory.

Soils and Manures.

As in former years, the soils received were associated either with crop failures, of the problem of manurial ingredients. The considerable increase in the number of soils received is the direct outcome of the Land Fertility Scheme, and it has been confirmed that large areas of the Province are very deficient in lime and phosphate.

Limes and Limestones.

A number of limes and limestones were received from producers who required an analysis to submit to the Land Fertility Committee. In addition, some limestones were sent in for opinion as to their agricultural value and to the possibility of their being ground on a commercial basis. In one or two cases, they were found to contain excessive quantities of silica. A number of waste lime products were also received.

Feeding Stuffs.

Most of the foodstuffs were sent in for microscopic and chemical analysis, because they were suspected of causing digestive or other troubles in farm livestock. Only very occasionally was it established that the foodstuff was the main source of the trouble.

Waters.

The majority of waters received were from farmers who are attempting to improve their domestic and dairy water supplies. In addition, there were some instances where the water was suspected of causing trouble with livestock. One case was examined for the Wiltshire County Constabulary in which following the cleaning out of what was a very dirty pond most of the fish were found dead. After investigation, the death of the fish was attributed

to the stirring up of the mud and organic matter from the bottom of the pond during the cleaning process, whereby the water became exhausted of oxygen. Cattle are drinking this water with no apparent harmful effect, now that the bottom of the pond has settled down again.

Poultry and Grassland—Poultry Manure.

The publication by the University of Bulletin No. 20, "The Maintenance of Grassland for Poultry" and "The Value, Storage and Utilization of Poultry Manure," by A. W. Ling and W. R. Muir, has stimulated interest in the management of grassland for poultry and in the storage and utilization of poultry manure.

Investigational.

(a) Grassland.

(1) Nitrogen and Mineral Uptake of Herbage.

The laboratory work in connection with this experiment is in course of completion, and it is hoped that an appropriate publication will be issued in due course.

(2) Composition of Hay.

Fifty-two farms are now included in the survey which commenced a year ago, and these are situated on eighteen different soil types. The number of farms will be increased as time and opportunity permit.

Preliminary data reveal that, on certain farms, the mineral content of the hay is very low, and below the level necessary if the minimum requirements of cattle and sheep for calcium and phosphorus are to be supplied by hay alone. This is an important consideration, for store stock subsist in the winter months largely on hay and roots. It is intended to discover whether any relation exists between this low mineral content of the hay and the health and constitution of the store cattle and sheep on the farms in question.

This investigation is being carried out in collaboration with the Education and Experiments Committee of the Bath & West Society, which has made a special grant towards the cost of the investigation.

(3) "*Lime*" Value of Basic Slag.

In March, 1937, the British Basic Slag Corporation made a special grant towards the cost of an experiment designed to determine the "lime" value of high and low phosphatic slags.

Data for the first two years of the experiment indicate that, in its effect on the yield and composition of herbage, a top-dressing of basic slag is equal to a combined dressing of superphosphate and ground limestone, containing equivalent amounts of phosphoric acid (P_2O_5) and lime (CaO). The lime value of high-citric soluble slag is therefore measured, for the first two years after application, approximately by its total calcium oxide content. (This is almost completely soluble in 2% citric acid solution).

(4) *Poultry and Grassland.*

In view of the pressing need for accurate information on this subject, continued attention has been given to the interaction between poultry and grassland, although financial and staff assistance are inadequate for any detailed investigation of the problems involved.

(a) *Manurial Effects.*—Plans have been prepared for experiments designed to measure direct and cumulative manurial effects of poultry folded on grassland, and of the residual values of poultry rations.

In collaboration with the Gloucester County Council Education Sub-Committee, experiments on these lines will be commenced at two centres in the autumn 1938.

In collaboration with the County Poultry Instructor for Somerset, field demonstrations have been conducted on a commercial farm near Cannington, Bridgwater. In 1938, on poor phosphate and potash deficient meadow land, the yield of hay was increased from 12.4 cwt. to 34.2 cwt. on plots where poultry had been folded during the previous winter. At the same time, the lime and phosphoric acid contents of the herbage were increased by 16%. Furthermore, there was a marked reduction in the weed flora, particularly in ox-eye daisies (*Chrysanthemum leucanthemum* L.).

The value of folded poultry as a means of controlling weeds on grassland is deserving of wider investigation.

(b) *Poultry Pens.*—The maintenance of permanent grass runs for poultry presents a special problem in grassland management.

and in order to meet the growing demand for advice on this subject, a study of the chemical and biological factors concerned is being continued as far as time and circumstances permit.

(5) *Chilean Nitrate Experiment.*

A large scale grassland experiment has been laid down, in collaboration with the Chilean Nitrate Corporation, at the Research Station, Long Ashton, in order to obtain precise information as to the value of Chilean Nitrate on grassland which has previously been manured with phosphates and potash.

(6) *Sugar Beet Waste Lime Experiments.*

The investigation which was commenced in 1935, in conjunction with the West Midland Province and the Allscott and Kidderminster Sugar Beet Factories, has been concluded and the findings published.

The experiment has now been re-designed in order to examine the value of sugar-beet waste lime on acid grassland, and observations will be made on the botanical and chemical changes in the herbage over the next few years.

As far as the Bristol Province is concerned, one centre has been established in Worcestershire.

(b) **Arable Land.**

(1) *Fertilizer Value of Dried Poultry Manure. Ministry's Scheme of Field Experiments.*

The experiment at South Petherton, Somerset, was continued for a second year. It is designed to measure the residual and cumulative values of dried poultry manure. The 1937 crop was sugar beet followed by early potatoes, and then savoy in 1938. The 1939 crop will be sugar beet.

It was not possible to find suitable centres for such crops as lettuces, tomatoes, etc.

(c) **Miscellaneous.**

Green Yolks in Eggs.

"Green yolk" is a fault in table eggs which may affect a large proportion of the supply from a given farm, with consequent

financial loss to the producer. The fault is detected by candling, and on breaking the egg, the surface of the yolk is found to be olive-green, while the white is a light fluorescent green. The factor (or factors) responsible for the fault is at present unknown.

At the request of Mr. J. C. Parkinson, of the Marketing Division, Ministry of Agriculture and Fisheries, the conditions of husbandry under which the production of green eggs was known to occur were investigated on three farms within the Province. Particular attention was paid to the health of the birds, the hygienic conditions and to the flora of the grassland on which the birds ranged.

The occurrence of green yolks in eggs is commonly attributed to the eating of such weeds as shepherd's purse, penny cress, etc. Careful search on the farms in question revealed that these weeds were either absent from the range or present in such small amounts that they could be dismissed as causative factors. A report on this preliminary investigation has been submitted to the Ministry.

General.

Towards the latter part of the year under review arrangements were made for the carrying out of a lime phosphate deficiency survey in backward areas in the Province. Two field men—Mr. R. A. Pullin, M.R.A.C., N.D.A., and Mr. F. J. Marshall, N.D.A.—were appointed for sampling and mapping in the field, and the assistant laboratory staff has been augmented to cope with the increased number of soil samples to be examined.

The collaboration of the County Agricultural Organizers in the Province was sought, and detailed plans have been made for the survey in each of the counties of the Province.

Broadcasting.

Thirty-five evening broadcast talks to farmers were given in the West of England and National Programmes. Other Advisory Officers attached to this centre and other counties, and research workers from Long Ashton Research Station, as well as farmers and growers, have participated in these talks.

Lectures.

In addition to the usual course of lectures given in the University,

six lectures were given to outside bodies on a variety of subjects, and fifteen articles were published in scientific and/or technical journals.

DAIRY BACTERIOLOGY.

Requests for advice received during the period under review numbered 1,540 as compared with 1,241 for the preceding period. The number of samples of milk and dairy products dealt with was 14,778 as against 14,521 for the previous year.

This increase in requests for advice is all the more gratifying because advisory work had to be almost completely suspended for three months on account of the presence of Foot-and-Mouth Disease in the Province. The main reasons for the increase have been a revival of interest on the part of producers wishing to obtain graded milk licences—particularly in Wiltshire during the past six months—and a larger number of advisory problems arising in Somerset.

Competitions.

The thirteenth annual clean milk competition conducted in Worcestershire proved very successful, all entrants obtaining a certificate of merit. A similar competition, the third to be organized by the Gloucestershire Milk Recording Society, concluded satisfactorily, and another competition has been commenced.

To further stimulate the interest in high grade milk production, the Wiltshire Smallholdings Committee arranged a clean milk competition open to County Council Smallholders. Although the number of entrants was small it was, nevertheless, encouraging, and the standard of production throughout the competition was very high.

Advisory Schemes.

The organized advisory scheme in Wiltshire is now on a sound basis, and the membership remains very similar to that of last year.

Efforts to organise an advisory scheme in Worcestershire, mentioned in last year's report, proved successful, and 31 members, who submit samples for bacteriological examination at monthly intervals, are now enrolled.

A large number of samples have again been dealt with in connection with the Gloucestershire Advisory Scheme. Here the primary object of the work is to assist milk producers who are applying for a graded milk licence or who have failed to maintain the necessary bacteriological standard for post-licence samples.

Private Samples.

Although fewer private farmers' samples have been received this year, it is pleasing to record that the dairy trade has continued to make use of the provincial laboratory, and efforts are being made to further extend this connection.

It is also worthy of note that an increased number of samples has been examined for Local Health Authorities this year.

Official Graded Milk Samples.

Examinations for the County Councils of Wiltshire and Gloucestershire continue to be conducted by the University at this centre. The number of graded samples examined exceeds that for the preceding period by more than 700.

Special Advisory Work and Investigation.

Advisory problems concerning the production and handling of milk in general have again been numerous, especially during the summer months, and the Dairy Bacteriologist has, on several occasions, found it necessary to visit the farms involved in order to make a thorough investigation. In all, forty-two advisory visits have been made to farms and dairies.

Cheese Problems.

More than the usual number of problems under this heading has been brought to the notice of the Dairy Bacteriologist. In the main, the problems were related to "slow" cheese, and to gassy curd. In connection with the "slow-working" of cheese, in some of the cases investigated it was impossible to trace the cause to the activity of inhibiting bacteria, and it was felt that some other obscure agency was responsible. The incidence of gassiness in cheese curd was greater than in recent years.

An interesting case of ropy whey accompanied by gassy curd

has been investigated when a coliform organism of the atypical kind was found to be responsible. The contamination was traced to the pipe-line of the releaser milking machine, and was also found in abundance in the dairy water supply.

Dairy-Water Supplies.

An increased number of dairy water samples has been examined. From the results obtained, it is apparent that supplies derived from many local springs and wells in rural areas are not of satisfactory standard for dairy work. During, and immediately following, the prolonged drought of the spring and early summer the bacteriological quality of several well supplies became increasingly bad. The use of such water was, in some instances, proved to be the cause of severe gassiness in cheese curd—due to coliform organisms contamination.

Coliform Mastitis.

An instance of coliform-infected milk, due to *B. coli communior*, has been investigated. The cow affected had, a few weeks previously, sustained an injury to one quarter by barbed wire. The wound had healed normally and from outward appearances looked quite healthy, but a small abscess which penetrated the udder tissue was found to be the seat of infection. Clinically, no abnormality could be noticed in the milk as drawn until pressure was applied immediately over the site of the old wound.

Milk Churns.

Interest in the bacteriological condition of milk churns as returned by buyers has been maintained, and a considerable number of churn rinsing samples examined. The results of these examinations are used in an advisory capacity whenever the bacteriological state of churns is regarded as unsatisfactory, and it is pleasing to record that in a few instances immediate improvement in the cleansing of churns has been apparent.

Butter-Fat Content of Milk.

Probably on account of the abnormally dry weather prevailing during the spring the incidence of low fat content in milk was higher than usual.

Much of the work of testing samples, under the Ministry's Butter-Fat Testing Scheme, for the Bristol and Somerset Milk Recording Society has now passed into the hands of recorders who have become qualified to conduct the test.

Methylene Blue Reductase Test.

Work has again been limited to studies of certain aspects of the Methylene Blue Reductase Test. The co-operative experiments on the value and reproducibility of the test, referred to in the previous report, have been concluded.

A number of samples has been examined to obtain data on the effect of various holding temperatures on the reduction time of milk.

The value of insulated boxes for the transport of milk samples to the laboratory is being tested in collaboration with the National Institute for Research in Dairying.

AGRICULTURAL ECONOMICS.

Farm Management Survey.

The second year of the Farm Management Survey was completed under difficult circumstances. The prevalence of Foot-and-Mouth Disease at the time when the records were due to be taken made it necessary to cancel the great majority of visits to farms. As a consequence, a delay of almost three months occurred before the records could be completed. It is satisfactory to state, however, that altogether 180 farm accounts were finally analysed and tabulated as compared with 143 for the previous year.

The acreage included in the Survey totalled 63,700 acres, thus giving an overall average of 354 acres per farm. This average, however, includes 33 Wiltshire Down farms of an average size of 925 acres.

The cash profit averaged seven shillings per acre, but there were wide variations from this figure.

Economics of Milk Production.

The special enquiry into economics of milk production commenced, in the autumn of 1934, on behalf of the Milk Marketing Board, has

now been completed for the fourth year. The number of farmers co-operating has been well maintained, and the statements of costs issued from time to time have been received by farmers with considerable interest. A good deal of advisory work upon hay qualities and rationing generally has been the outcome of such cost statements.

Seventy-six farms kept weekly records of costs for the winter of 1937/38. The average cost of production worked out at approximately 11½d. per gallon, although, as usual, there was a wide range of costs. This is exclusive of a charge for the value of autumn and winter grazing and of the cost of herd replacement. Of the 76 farms, exactly half were accredited producers, and in addition there were eleven others producing T.T. milk.

Fifteen farms had milking machines and of these five possessed an open-air bail.

The same number of farms co-operated in the inquiry for the summer of 1938, and the work of calculating individual costs is now proceeding. The average cost amounts to 7½d. per gallon.

The research carried out in this department into the economics of milk production has been continued during the past year. Emphasis has been placed upon the relative importance of purchased concentrates, hay, roots and greens, and grazing in the feeding of the dairy herd. The data given below are arithmetical averages drawn from a sample of 50 herds for which details are available for three complete years, from October 1934 to September 1937.

Quantities of concentrates, hay and straw, and roots and greens are given in the following table:—

QUANTITIES PER COW PER DAY.

Year (ending September).	Concentrates.	Hay and Straw.	Roots and Greens.
	lbs.	lbs.	lbs.
1934-5	5.62	7.5	8.0
1935-6	5.65	8.0	5.7
1936-7	5.34	7.1	5.2

Since these figures are averages for a whole year, it follows that

the figures are much higher in mid-winter, and much lower in mid-summer. The average yield of milk being 1.75 gallons per day per cow-in-herd, it is found that, taking the year as a whole, over 3 lbs. of concentrates are fed per gallon. The recognised standard is $3\frac{1}{2}$ lbs., assuming that no grazing is available for the production ration. The quantity of cake fed is such that the *effective* value of grazing is limited largely to the maintenance ration. During certain summer months, grazing makes a valuable contribution to the production ration, but this contribution is very largely offset by excessive cake feeding in winter due to poor hay quality. In March the concentrates ration approaches 5 lbs. to the gallon. A clearer picture of concentrate-feeding is provided by the following table :—

CONCENTRATES.

Year.	Yield per day per cow-in-herd.	Concentrates per gallon.	Concentrates cost per gallon.	Price paid per ton.
	Gallons.	lbs.	d.	£ s. d.
1934-5	1.73	3.20	2.49	7 5 0
1935-6	1.76	3.21	2.41	7 0 0
1936-7	1.74	3.07	2.59	7 17 0

A part of the surplus cake was removed during the third year, owing, doubtless, to the higher cost of cake. The grassland was "squeezed" under favourable weather conditions. The Department has stressed the point that the quantity of cake should not again be increased when its price falls. In order to prevent this, the problem of grassland improvement must be considered, since weather conditions cannot be relied upon to prove favourable whenever cake prices prove unfavourable.

Pig Survey.

During 1937 fourteen farmers co-operated with the University in an inquiry into the economics of pig production. There was, as usual, a wide range in the size of the pig department on these farms, but space does not permit of any individual data being given.

The two largest items of expense, foods and labour, accounted for 75% and 8% respectively of total income.

Only three farms fed home-grown foods and even then the foods seemed to form no part of a definite system of feeding. Two farms, only, used whey or separated milk, and these were largely dependent upon purchased supplies. Other farmers in the Survey recognized the feeding value of these commodities but stated they were unable to obtain supplies.

Of the fourteen farms whose complete records were obtained, nine sold bacon pigs by grade, and the average grading results for these nine farms, although they varied considerably farm by farm, worked out as follows:—

					<i>Per cent.</i>
Proportion of bacon pigs as	Grade A	..	57		
" " " " "	Grade B	..	34		
" " " " "	Grade C	..	9		
					100

The average number of pigs weaned per litter was 7.4. Ten pigs per litter were born alive so that 25% of these were lost between birth and weaning. Of a total mortality of 960 pigs, 835 died at less than 8 weeks old, 118 between 8 and 16 weeks, and the remaining 7 at over 16 weeks old. Of these 960 deaths, records were kept by some of the farmers for a total of 465 deaths, and in nearly all cases the cause of death was able to be given.

Poultry Management.

This inquiry, continued from previous years, has proved to be of considerable interest to poultry farmers in the Province. Although, on account of pressure of work in other directions, it has not been possible to include more than fourteen farms, the intensive nature of the investigation has enabled a great deal of useful information to be gained.

The capital invested in these farms, apart from the value of the land itself, ranged from £30 to £970. Three of the farms each had a capital of less than £100, while four had over £500. The two farms with the smallest capital made the smallest profits, but on the other hand another farm, with only £78 capital, made the third highest profit, relatively speaking. Among those showing losses were the two largest enterprises. The farm with the highest profit had a capital of something over £350, and the one with the heaviest loss a little over £200.

Over all the farms the proportions in which the capital was distributed was as follows :—

Housing and fences	35%
Equipment	12%
Livestock	50%
Foods and supplies on hand ..	3%
	100

It is perhaps not so much the ratio of food costs to total costs that matters so much as the ratio of food cost to total income. It was found that the average sales from the farms co-operating in the Survey amounted, for the year under review (1937), to £509 per farm, and the average cost of feeding stuffs to £301 per farm, namely a proportion of 59 per cent. Examination of the survey records over the past three years shows, however, that this proportion was highest in 1937, mainly owing to the rise in the prices of feeding stuffs which had its greatest effect in that year. Thus, in 1936, with average sales of £588 per farm and an average feeding stuffs cost of £311 per farm, the proportion comes out at 53%, while for 1935 the figures are £637, £314 and 49% respectively.

It must not be assumed that the general average increase in the relative cost of feeding stuffs during the last three years is due solely to the rise in prices of feeding stuffs. The sales per farm have not increased in value commensurate with the rise in the cost of foods, in spite of the rise in the prices of eggs. Moreover, as prices of feeding stuffs rise, farmers pay more attention both to rationing and to the elimination of waste. This extra care has the effect of checking the rise in the proportion of the cost of foods to output. Further, an improvement in methods of management which would result in higher egg yields during the months of high egg prices would also offset additional expenditure due to rising prices of feeding stuffs.

Average egg prices for the three years received by the farmers co-operating were as follows :—

1935.	1936.	1937.
13 $\frac{3}{4}$ d. ..	14 $\frac{3}{4}$ d. ..	16d. per dozen.

The majority of the farms relied mainly on the sale of commercial eggs, but the range, farm by farm, was from 9% up to 85%. Only five of the fourteen farms sold hatching eggs, but on these five such sales were of considerable importance.

Although table poultry was the second largest single item of income, it was found that on no farm were birds being reared for table purposes on a large scale. The sale of table poultry was rather a means of disposing of culled birds than a definite part of the farm system.

Only one farmer had successfully tackled the problem of drying manure inexpensively, and he had a demand for the dried manure which was not only remunerative but exceeded the supply.

VETERINARY SCIENCE.

Enquiries and Advisory Work.

Close co-operation has been maintained with veterinary practitioners and agriculturists in investigations into obscure outbreaks of disease during the year. Work has proceeded on normal lines and the demands for assistance from practitioners and requests for advice from farmers have been fully maintained.

494 enquiries were received, and 658 pathological specimens examined in the Laboratory.

In connection with work on disease eradication, 942 samples of bovine blood were subjected to the agglutination test for contagious bovine abortion.

Survey and Intelligence.

Sheep. A number of outbreaks of parasitic gastritis were encountered last autumn due to infestations of *Ostertagia* species, and in one outbreak *Trichostrongylus* sp. were responsible.

Severe losses due to contagious pustular dermatitis occurred on one farm in February. The lesions were most severe on the udders of the ewes, secondary bacterial invaders setting up acute mastitis with abscess formation. A number of ewes died and the lambs from all the affected ewes had to be weaned immediately the udder became involved. The lesions on the lips of the lambs were comparatively mild.

Cattle. Extensive blood tests of cattle on five farms have been carried out for the control of contagious bovine abortion. Disposal of reactors has been carried out on two farms, and disease-free herds

have been satisfactorily maintained up to the present time. On two other farms infection was so widespread that the future policy is still under consideration. Segregation of reactors is being carried out in one instance where two adjoining farms are under the same ownership.

Parasitic gastritis of young cattle has been particularly prevalent during the summer months. Seven outbreaks within an area of five miles were investigated during September. Losses by death varied from 8 of a batch of 13, to 1 out of a batch of 16 yearling calves. Post-mortem material was scanty and only one carcase was available for examination, a heavy infestation of *Trichostrongylus* species being present.

One rather unusual case was encountered where cows on one farm failed to "spring in the udder," and after calving gave 1-1½ gallons of milk and dried off within a few weeks. This only occurred among cows which were on the farm 12-18 months. In-calf animals brought on to the farm milked normally. An unsuccessful attempt was made to fatten the poorest milkers, and accordingly one was killed. The autopsy revealed extensive cirrhosis of the liver and a very heavy infestation of *F. hepatica*.

Pigs. Anaemia continues to be a source of loss among young pigs on certain farms where a run on grass is not always available for the litter.

One outbreak of pig pox with heavy loss among suckling pigs was encountered.

Investigational.

The time taken up with routine work in connection with the control and eradication of disease in dairy herds has not permitted the undertaking of elaborate investigations. The Investigation Officer has instead maintained co-operation with the laboratories at Cambridge and Weybridge, forwarding details of outbreaks and suitable specimens to the laboratory concerned with research on that particular disease.

Lectures.

A course of lectures on Veterinary Hygiene was given to students at the Somerset Farm Institute last autumn. Ten lectures on animal diseases were delivered to farmers in the Province at the

following centres :--Atworth, Pewsey, Yeovil, Chipping Sodbury, Dursley, Stroud, Gloucester, Moreton-in-Marsh, Hereford, Worcester.

POULTRY PATHOLOGY.

The number of pathological specimens has again increased, and totalled 2,066. The total number of blood samples submitted to the agglutination test for Pullorum disease amounted to 50,098. In addition, 149 requests for advice on poultry matters were dealt with by the Poultry Pathologist.

In assisting the Veterinary Investigation Officer, 68 visits were made to poultry farmers in the Province.

All the more common diseases have been met with in the examination of adult carcasses, including tuberculosis, coccidiosis and other parasitic diseases, and Lymphomatosis. Pullorum disease and caecal coccidiosis continue to be responsible for heavy losses among chicks.

CIDER.

The total number of enquiries, including 212 arising in the course of the Cider Instruction Scheme, in which the counties of Dorset, Monmouth and Worcester participated, was 443.

Technical questions accounted for the greater proportion of the total enquiries, and there was a considerable decrease in the general enquiries and those dealing with farm cider-making. The enquiries from other areas included several from Devon and a number from overseas, including Australia, Canada, New Zealand and Denmark.

A feature in the enquiries from farmers and growers was an increase in applications concerning advice in orchard management and selection of varieties for planting.

Several cases of "darkening" in cider were involved in connection with the enquiries, and many cases of cider "sickness" occurred later in the season. It is worthy of note that instances of Kingston Black cider being attacked by "sickness" were encountered on three occasions during the season.

Technical enquiries were concerned with the following subjects : suitable metals for cider plant ; a scheme for maintaining large

bulks of cider in a sweet condition by centrifugation ; economics of the drying of apple pomace ; supply of cultures of cider yeasts to breweries in England and Canada.

A large cider-making factory in the eastern counties sought advice concerning their methods of cider making and bottling. A considerable amount of time was spent in this connection, and a completely new system of management was worked out to suit the special needs of the factory.

The recent introduction of the use of enzymes capable of effecting changes in the pectic constituents of cider has resulted in a number of enquiries being received relating to the method of use and the probable benefit accruing from such a system of clarification. The results obtained by cider makers have been variable, although complete prevention of the deposition of white flocculent material in bottled ciders has been satisfactorily achieved in one case. The whole matter is now being investigated through the research programme.

Many enquiries have been received concerning the irregularities in the system of natural conditioning of ciders. The member of staff responsible for technical problems has been approached by the Adviser in Cider Making for Somerset regarding the use of pasteurization as a means of stabilizing naturally conditioned ciders. Definite advice on a new problem of this nature could not be given until further work had been carried out with the special pasteurizing apparatus which has been purchased for this purpose.

The Director of the Station and members of the staff associated with cider subjects were responsible for the organization of two tasting functions for the Wine and Food Society at which ciders of various types, ages and characters were made available.

The Cider Instructor paid 156 visits to farms in the three counties concerned with the scheme, whilst 44 additional visits to farms were made in connection with the Cider Orchard Survey Scheme which was commenced this year.

The Dorset scheme was in abeyance as far as actual visits were concerned from September to March on account of the widespread restrictions owing to Foot-and-Mouth Disease. For this reason, much new work which was beginning to show promise in North Dorset suffered for want of personal contact. By March the management of the ciders had, in many cases, been too long neglected to give satisfactory results. A big proportion of the Instructor's time has been devoted to farm orcharding problems

in connection both with old orchards and with the acreage of new orchards in the county.

A preliminary examination of the soils has been made in the district between Bridport, Beaminster and associated areas.

In Monmouth, the Instructor supervised the work of the Cider Department at Usk, where new filters have been acquired and have been in constant use. Help has been given in the laying out of further orchards at the Usk Institute.

A surprisingly large amount of cider has been made in the Pershore and Evesham districts of Worcester. Although the quality has been rather rough, attempts have been made to produce a superior cider from such material, and the filter process has been demonstrated in this connection. In the pursuance of the Soil Survey Scheme, 30 orchards of cider trees have been visited largely in the area between Bushley and Malvern.

In general it may be said that farm cider-making continues to be profitable, and that in most cases the bottled trade pays the farmer best. The problems connected with the production of a stable, naturally-conditioned cider free from deposit are being examined in detail, and the possibilities of pasteurization are being considered.

FRUIT PRODUCTS.

The total number of enquiries received during the year was 621. This represents a reduction on the previous year of 40, but the detailed nature of the bulk of the enquiries, many of which required attention for periods extending over several days, has resulted in a considerable addition to the volume of work and has contributed in no small degree to the difficulties which have been encountered in carrying out the combined research and advisory sections of fruit products work.

The enquiries from areas outside the Province included the following: Cambridgeshire (20), Devon (21), Essex (2), Kent (30), Sussex (16), Australia (27), Canada (11), New Zealand (20), India (11), Nigeria (2), U.S.A. (17), Germany (2), Czecho-Slovakia (2), France, Spain, Denmark and Sweden.

During the year various general or specific questions concerning fruit products were discussed with 131 visitors on different occasions. These interviews occupied a total of 50 complete working days.

Apple Juice.

A feature of the enquiries is the remarkable interest which has been shown in apple juice. Following the publication in the Long Ashton Annual Report for 1937 of a new method for apple juice production, many enquiries were received concerning large-scale production, and a firm of fruit growers in Sussex commenced manufacture under the supervision of the Adviser, using the Long Ashton method in its entirety. Advice has been given regarding the planning of buildings for apple juice production. In two cases (Hereford and Kent) existing premises have been examined and advice given as to their suitability for this purpose.

The unsatisfactory weather conditions during the autumn of 1938 caused much damage to the type of apples used for juice production. Fermentation was liable to occur during the pre-clarification treatment and the Adviser was in daily telephonic communication with producers (often at unusual hours of the night), regarding the treatment necessary under the various specific conditions existing in the factories. Such circumstances as these, where considerable bulks of juice are involved, have imposed an additional strain on the advisory service. In order to avoid an excessive interference with the other work of the Fruit Products Section, it has been necessary to arrange for seven discussions to take place at the Research Station on Sundays.

Fruit Syrups and Aerated Juices.

The previous arrangement between Messrs. H. W. Carter & Co., Ltd., Bristol, and the University of Bristol, whereby the services of the Fruit Products Officer were placed at the disposal of the firm in the summer of 1936 and 1937 in order to take control of the soft fruit syrup manufacturing programme, was not repeated in 1938. However, a number of problems arose which were of a most important character and connected with the firm's pioneer work in connection with pure fruit syrups. These claimed the attention of the Products Officer at a time when apple juice and cider enquiries were equally insistent.

Therapeutic Values of Juices and Syrups.

The services of the Products Officer have been sought by medical practitioners and specialists regarding the provision of apple juice and black currant syrup for the treatment of Pink Disease

(erythroedema) and duodenal ulcer cases respectively. Juices and syrups of known composition were supplied from the Department, and cures of a definite character have been reported.

Orange Juice.

By arrangement with the Agricultural Department of the Colonial Office, a series of tests were carried out on the treatment of orange juice from Jaffa oranges from Palestine by the de-aeration and flash pasteurization method used at Long Ashton for apple juice. Advice was given as to the suitability of these processes.

Pineapple Juice.

Pineapples received from the Agricultural Officer at Agege, Nigeria, were processed into juices, syrups and squashes, in order that definite advice could be given relative to the suitability of Nigeria pines for the production of beverages for local consumption or for export abroad.

Carrot Juice.

The production of carrot juice in this country has been attempted by a commercial firm, and advice has been given regarding the acidification of the juice for the purpose of suppressing any possible development of the *Botulinus* organism.

Tomato Juice.

A number of enquiries were received on the subject of the utilisation of certain grades of tomatoes by the production of a cloudy juice. The great obstacle to the development of this particular process in this country appears to be the high price demanded for the fruit.

Fruit Wines.

These enquiries dealt with the possibility of introducing a new series of light alcoholic wines from English fruits to replace the existing types of sherry and port style wines during the summer months when the demand for the latter type is greatly reduced.

Indian Enquiries.

Special mention should be made of a series of enquiries from various parts of India. These have dealt with the following subjects: utilisation of various indigenous fruits for pectin extraction; use of oranges for production of pure juices; fermentation of orange and other juices with sherry yeasts; standardisation of citrus squashes, syrups and cordials from Indian fruits.

German Conference.

The Products Officer attended the 12th International Horticultural Congress in Berlin in August 1938 and, in his capacity of General Reporter for Section II, "Processing and Industrial Utilisation of Fruit and Vegetables," delivered a lecture to that section on "Fruit Beverages." Following the Conference an investigation into the apple juice industry in Germany was carried out, the chief centres of production were visited and discussions with Government and industrial administrators and technicians enabled a detailed knowledge of the industry to be obtained.

POMOLOGY.

585 enquiries were received, of which 176 came from sources outside the Bristol Province. The total was 76 less than in the previous year, the decrease being probably due in great part to the lack of crop in 1938 following the spring frosts.

The enquiries included 12 from overseas. They covered all the main aspects of fruit culture, and included many relating to problems of orchard planning, pruning methods and spraying technique. The usual large number of fruits, mainly apples, were received for identification.

Forty-two advisory visits were paid to commercial fruit farms.

The usual large number of visitors were received at the Research Station by the pomological staff, who also acted as guides for numerous organized parties.

HORTICULTURAL CHEMISTRY.

181 requests for advice, including 83 from outside the Province, were received. Fourteen enquiries came from overseas, Australia, Canada, New Zealand, India, Kenya, Argentine, France, Holland and the U.S.A. being represented among these.

The main subjects of enquiry concerned nutritional problems relating to fruit trees and garden and glasshouse crops, and there was a notable increase in the requests for advice relating to the suitability of soils and sites for planting fruit. The number of enquiries regarding fruit quality, storage and "physiological diseases" of fruits reflects the interest taken in the production of fruit of high quality.

Special Investigations in Progress.

1. *Control of Lime-induced Chlorosis in Apples, Pears and Plums—in Somerset and Worcestershire.*

Trees treated by the ferric citrate method in 1937, at all centres, continued to be healthy, but a few trees at one centre treated prior to 1937 were slightly chlorotic, indicating that the treatments were losing effect.

2. *Manurial Experiment on Apples—in Herefordshire.*

The trees continued to develop in an entirely satisfactory way. The 1938 crop was light, due to frost.

3. *Manurial Experiments on Asparagus in Worcestershire.*

The experiments at Perdisswell and Sedgeberrow were continued, and detailed cropping records were obtained for the third season. Crops at both centres were light, due to frost and drought effects. Growth of the bower in both cases was very strong, probably as the result of the light crops and of favourable weather conditions for vegetative growth during the summer. There are still no observable effects to date, due to the manures, at either centre. The plots were again inspected by organized parties of local growers who continue to take great interest in the experiments.

ECONOMIC ENTOMOLOGY.

The number of enquiries (640) concerning agricultural and horticultural pests did not show any appreciable variation from the previous year. The main subjects of enquiry related to the following :—Fruit Aphides, Fruit Tree Red Spider, Greenhouse Red Spider on Hops, Phyllobius Weevils, Chafer Beetles, Cabbage Root Fly, the Hop Strig Maggot and the atomization of insecticides.

Spray Programme Service.

The Spray Programme Service dealing with the control of fruit pests was continued, and arrangements were made for the better distribution of the information to growers.

Investigations in Progress.

Winter Washes.

Field and laboratory experiments were continued on the ovicidal and phytocidal properties of various materials that had proved of promise in preliminary laboratory evaluation tests. Attention was given in particular to the use of dinitro-cresol washes in various combinations.

Control of Pests of Nursery Stock.

Experimental work was continued on the joint control of Aphides, Woolly Aphid, Red Spider, Apple Sucker, Winter Moths and Capsids on nursery stock by means of dipping the trees into washes prior to planting.

Combined Summer Washes.

Experiments were continued and valuable data were obtained on the phytocidal properties of oil combinations applied at the periods coinciding with frosts.

Laboratory Evaluation of Insecticides.

Investigations were continued on the use of pests as test insects.

Particular attention was given to methods of employing Winter Moth eggs for the evaluation of the ovicidal properties of winter wash materials.

Fruit Tree Red Spider.

Field trials were continued on the use of petroleum oils and organic thiocyanates as means of controlling the winter eggs of Red Spider ; a satisfactory method of evaluating the results of field treatments has been evolved.

Atomization of Insecticides.

A survey has been made of equipment that is in commercial use for the application of atomized fluids. Much of this equipment has been tested and its uses for the application of atomized insecticides has been examined.

Control of the Cabbage Root Maggot (*Chortophila brassicae*).

Extensive field trials, using a single fluid application of calomel, were carried out near Evësham. In spite of adverse conditions due to drought, which delayed application beyond the optimum date, an infestation of 16.3% was reduced to 4.7% on the treated plots. Preliminary trials with dilute chloric acid ($\frac{1}{100}$ %), reported as in successful use in Soviet Russia, were commenced at Long Ashton.

Control of Ant Hills in Pasture Land.

In response to numerous enquiries, field trials have been arranged using various methods.

The Control of the Hop Strig Maggot (*Contarinia humuli*).

Following severe infestations, more particularly in Herefordshire, field trials were commenced, using derris powder at the time when the larvae leave the cones, but were vitiated by wet weather and light infestations.

Bionomics of the Mite, *Tarsonemus spirifex*, on Oats.

Further infestations in Wiltshire enabled arrangements for observational plots to be made.

ECONOMIC MYCOLOGY.

The number of advisory enquiries was 542, compared with 498 in the previous year.

The following report gives a brief summary of the progress of research during the period under review.

Mr. C. J. Hickman left to take up an investigation of strawberry root rot, under the Agricultural Research Council. Mr. H. E. Croxall, B.Sc., of Birmingham University, was appointed Assistant in Vegetable Diseases, and commenced duty on April 25th.

Mr. D. L. Godfrey Davies completed his work on "Fusarium Diseases of Crops in the Bristol Province." Mr. E. H. Wilkinson continued post-graduate research on "Apple Fruit Rots and Spots." Mr. A. F. Parker-Rhodes is continuing, at Long Ashton, work which he had initiated at Cambridge on "The Toxicity to Rust Uredospores of certain Substances obtained from the Wheat Plant."

Investigations.

Cereal Diseases.

Extensive culture work was carried out on cereals which had "failed" in the Wiltshire area. The pathogenicity of these cultures is to be ascertained later.

Seed Protectants.

The work on seed protectants has been continued. Field trials have indicated that large increases in "stand" may be expected from the use of cuprous oxide or organic mercury dusts on peas, especially during the winter months. Further work has been concerned with the specificity of the reaction of pea varieties to these dressings, with possible stimulation or check to growth, and how the latter can be prevented.

Increases in germination followed cuprous oxide treatment of the following seeds:—Pea, sugar beet, tomato, cucumber and sweet pea. Zinc oxide gave increased germination in the case of cabbage, turnip, radish, lettuce, wallflower, stock, cosmos and antirrhinum.

Damping-off.

As indicated on page 98, weak solutions of formalin were found useful in protecting pea, sweet pea, cucumber and tomato seeds from damping-off.

Miscellaneous Vegetable Diseases.

These are reported on in "Progress Report on Vegetable Diseases—X" (p. 91).

Bacterial Disease of Begonias.

Investigations on this disease have been completed and a paper published in conjunction with Dowson and Moore. The organism is *Pseudomonas Begoniae* (Buchw.) Pape emend Dows. Infection is probably largely induced by watering the plants from tanks in which debris has been allowed to collect.

Lilies.

No improvement in emergence followed treatment of lily seeds of various species with cuprous oxide, zinc oxide or organic mercury dusts.

Miscellaneous Diseases of Ornamentals.

Bacterium Syringae was very prevalent on lilacs in a nursery in South Somerset. *Uredo Fuchsiae* was common on fuchsias in a Cheltenham nursery. *Verticillium Wilt* occurred on Coleus in Bath, while *Thielaviopsis basicola* caused a root rot of larkspurs, as previously described from delphiniums in this area.

A mosaic disease was common on St. Brigid Anemones from Dutch corms at Cheddar, causing mottling of the leaves and "breaking" of the flowers. Leaf curl occurred extensively on Pelargonium "Paul Crampel" in a nursery at Bath.

Hop Diseases.

A rootstock canker of hops is reported on by D. L. G. Davies on p. 115.

INSECTICIDES AND FUNGICIDES.

The enquiries received by post totalled 203, representing an increase of 47 over the previous year. 168 were from areas outside the Bristol Province, including 11 from overseas.

In addition to the 203 enquiries above, interviews were given on 44 occasions to growers, and to representatives of 23 different commercial firms.

The main subject of the enquiries was tar oil washes, but the range of miscellaneous subjects was large. The extension in subjects appeared due to the increasing tendency of manufacturers to pay attention to other than the usual insecticidal and fungicidal materials. Ten proposed substitutes for Bordeaux mixture and six for lime-sulphur were included in products submitted by makers for an opinion of their suitability for commercial production.

The enquiries entailed the analyses of 107 different spray materials, including 24 hydrocarbon oils, 31 oil preparations and 7 soap substitutes.

DOMESTIC PRESERVATION OF FRUIT AND VEGETABLES.

53 enquiries were received, of which 40 came from areas outside the Province. The total showed a decrease of 41 in comparison with the previous year.

The sources and natures of the enquiries were similar to those of previous years, the usual large proportion coming from County Officers.

Courses of Instruction.

A course of instruction for Produce Judges, arranged by the National Federation of Women's Institutes, was held at Seale Hayne Agricultural College, Newton Abbot, Devon, from April 4th-7th. Fifteen students, from various districts of England and Wales, attended the course.

Two ten-day courses in Fruit and Vegetable Preservation were held at the Royal Agricultural College, Cirencester, during the period August 9th-September 2nd. Each course was attended by 16 students, the maximum number possible.

Lectures and Demonstrations.

Demonstrations on methods of preparing candied fruit and peel were given on Cider Tasting Day at Long Ashton, when preserved fruits and vegetables were also exhibited.

A demonstration of fruit bottling and canning was given in the Wilts School of Domestic Science, at Trowbridge, on May 11th.

Committees.

The Instructress served on the Rural Domestic Economy Sub-Committee of the Gloucestershire Federation of Women's Institutes during the year.

WILLOW GROWING.

325 enquiries were received, of which 179 came from areas outside the Province. The total shows an increase of 106 over the previous year.

The main feature of the enquiries was the large number (234) relating to the cricket bat willow. A large proportion of these requests emanated from Land Owners and Estate Agents. The interest in the bat willow crop is doubtless due to the high prices given for good quality willow timber, and to the publicity which has been given recently to bat willow cultivation. Land naturally suited for the tree is widespread but is seldom extensive on a given site.

About 7,000 trees were planted on advice given by the Willow Officer, and schemes have been devised by him in cases where planting is to extend over a number of seasons.

In addition to enquiries concerning willow bat culture the usual types of enquiry relating to the cultivation, control of pests and diseases and marketing of rods of basket willows were received.

The early shoots of the basket willow crop were severely injured by spring frosts in 1938, but in spite of this good crops were harvested, due to the unusual absence of pests and diseases and to favourable weather conditions during late summer.

Lectures were given before various Societies, etc., at Ipswich, Warwick, Oxford and Apethorpe, and an exhibit demonstrating points of cricket bat willow culture was staged at the Royal Agricultural Society's Show at Cardiff.

PUBLICATIONS.

1938.

LONG ASHTON RESEARCH STATION.

Annual Report of the Agricultural and Horticultural Research Station in
the Bath and West Journal, 1937-38.

CHARLEY, V. L. S.

"Utilisation of Surplus and Low Grade Fruit." (Wores. County Council
Agricultural Quarterly Chronicle, pp. 129-137, May 1938).

"Curdling of Milk Shakes." (Dairy Industries, pp. 254-258, July 1938).

FAJANS, E. and MARTIN, H.

"The Incorporation of Direct with Protective Insecticides and Fungicides.
III. Factors affecting the Retention and Spray Residue of Emulsions
and Combined Emulsion-Suspensions." (J. of Pomol. and Hort.
Sci., Vol. XVI, No. 1, pp 14-38, March 1938).

MARSH, R. W.

"Some Applications of Laboratory Biological Tests to the Evaluation of
Fungicides." (Annals of Applied Biology, Vol. XXV, pp. 583-604,
1938).

OGILVIE, L.

"The Resistance of Dwarf Bean Varieties to Halo Blight." (Wores. County
Council Agricultural Quarterly Chronicle, Vol. 6, No. 3, p. 159,
May 1938).

OGILVIE, L., DOWSON, W. J., and MOORE, W. C.

"A Bacterial Disease of Begonia." (J. Royal Hort. Soc., Vol. 63, pp 286-
290, 1938).

SMYTH, ELSIE S.

"The Seasonal Cycles of Ash, Carbohydrate and Nitrogenous Constituents
in the Terminal Shoots of Apple Trees and the Effects of Five
Vegetatively Propagated Rootstocks on Them. II. Carbohydrate
Fractions and Lignin." (J. of Pomol. and Hort. Sci., Vol. XVI,
No. 3, pp 185-200, Sept. 1938).

SWARBRICK, T.

"The Modified Leader Tree." (Scientific Horticulture, Vol. VI, pp. 229-
241, 1938).

VAIDYA, V. G.

- "The Seasonal Cycles of Ash, Carbohydrate and Nitrogenous Constituents in the Terminal Shoots of Apple Trees and the Effects of Five Vegetatively Propagated Rootstocks on Them. I. Total Ash and Ash Constituents." (J. of Pomol. and Hort. Sci., Vol. XVI, No. 2, pp. 101-126, June 1938)

WALLACE, T.

- "A Field Experiment on the Manuring of Raspberries." (J. of Pomol. and Hort. Sci., Vol. XVI, No. 1, pp. 3-13, March 1938).
- "A Field Experiment on the Manuring of Black Currants." (*Ibid.*, Vol. XVI, No. 2, pp. 127-147, June 1938).

WALLACE, T. and VAIDYA, V. G.

- "A Field Experiment on the Manuring of Strawberries." (J. of Pomol. and Hort. Sci., Vol. XVI, No. 2, pp. 148-166, June 1938).

WALLACE, T. and GLEED, C. J.

- "Strawberry Manurial Experiments 1923-37." (Report of Experiments on Strawberries—Botley Fruit Experiment Station, pp. 31-34, April 1938).

BERKELEY SQUARE ADVISORY CENTRE.

BEARD, VIOLET G.

- "Variations in Milk Transport Charges." (Monthly Notes on Farm Economics, August 1938).

BLUNDELL, J. E.

- "Grassland Costs over Three Years." (Monthly Notes on Farm Economics, April 1938).
- "Comparison of Dairy Herd Feeding over Three Years." (*Ibid.*, June 1938).
- "Dairy Herd Feeding over Three Years (contd.)" (*Ibid.*, July 1938).

BLUNDELL, J. E. and WRAGG, W. R.

- "Comparison of Dairy Herd Labour for Three Winters." (Monthly Notes on Farm Economics, March 1938).

COOK, L. A. C.

- "Relative Cost of Foods in Poultry Management, 1935-1937." (Monthly Notes on Farm Economics, March 1938).
- "Egg Yield and Seasonal Production of Eggs, 1935-1937." (*Ibid.*, April 1938).

HEWETT, L. J.

- "Food Costs on Nineteen Somerset Cheese-making Farms." (Monthly Notes on Farm Economics, September 1938).

LING, A. W.

- "Maintenance of Grassland for Poultry." (Wilts. Advisory Report on Poultry Husbandry, pp. 10-20, January 1938).
- "Sugar Beet in the West of England." (Farmer and Stockbreeder, p. 334, February 8th, 1938).
- "The Management of Grassland." (Farmers' Weekly, p. 25, February 18th, 1938).
- "The Value of Young Grass for Poultry." (Farmer and Stockbreeder, pp. 693 and 695, March 15th, 1938).
- "The Maintenance of Grassland for Poultry." (Bulletin No. 20, University of Bristol, March 1938).
- "Investigations into the Value of Sugar Beet Factory Waste Lime." (Conducted and Published by the Joint Sub-Committee representing the West Midland and Bristol Provincial Councils and the Allscott and Kidderminster Beet Sugar Factories, July 1938).
- "The Manuring of Sugar Beet." (Journal of Ministry of Agriculture, Vol. XLV, No. 8, pp. 806-810, November 1938).
- "Soil Analysis." (Herefordshire Agricultural Quarterly Journal, Vol. 6, No. 4, pp. 112-117, Dec. 1938).

LING, A. W. and MUIR, W. R.

- "The Value, Storage and Utilisation of Poultry Manure." (Bulletin No. 20, University of Bristol, March 1938).

MUIR, W. R.

- "The Value, Storage and Utilisation of Poultry Manure." (Wilts. Advisory Report on Poultry Husbandry, pp. 67-77, January, 1938).

TRIST, P. J. O.

- "Profit and Loss on Pig Farms." (Monthly Notes on Farm Economics, May 1938).
- "Food Bill in Pig Production." (*Ibid.*, October, 1938).

CAMPDEN RESEARCH STATION.

ADAM, W. B.

"The Composition and Texture of Dried Peas: II." (Annual Report of the Fruit and Vegetable Preservation Research Station, Campden, Glos., p. 41, 1936-37).

"Hydrogen Swells in Canned Fruits." (Chemistry and Industry, 57, p. 682, 1938).

ADAM, W. B. and HORNER, G.

"The Presence of Tin in Canned Fruits and Vegetables." (Annual Report of the Fruit and Vegetable Preservation Research Station, Campden, Glos., p. 24, 1936-37).

ADAM, W. B. and STANWORTH, J.

"The Measurement of the Internal Capacity of Cans." (*Ibid.*, p. 57, 1936-37).

GILLESPIE, T. G.

"Studies on the Mould *Byssoschlamys fulva*: Progress Report." (*Ibid.*, p. 68, 1936-37).

HIRST, F. and ADAM, W. B.

"Fruit Gumming of Victoria Plums: Preliminary Report." (*Ibid.*, p. 17, 1936-37).

"Varieties of Vegetables for Canning." (Canners' Bulletin No. 6. Fruit and Vegetable Preservation Research Station, July, 1938).

HORNER, G.

"The Losses of Soluble Solids in the Blanching of Vegetables." (Annual Report of the Fruit and Vegetable Preservation Research Station, Campden, Glos., p. 37, 1936-37).

"Progress Report on the Mineral Content of Canned Vegetables: II." (*Ibid.*, p. 51, 1936-37).

"Canning and Agriculture." (Bath and West Journal, 12, p. 23, 1937-38).

